NAME THAT ANIMAL

A Guide to the Identification of the Common Land and
Fresh-water Animals of the United States,
with special reference to the area east of the Rockies

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PREFACE

The purpose of this book is to provide the reader with a practical key to the identification of land and fresh-water animals. We hope that it will unlock the door to the great number of more technical or more detailed treatises and thereby carry the inquiring student over the first and often most difficult hurdle on the road to a knowledge of animals. Because the literature of animal taxonomy is often not readily available and only too often not readily comprehended by the general student of animal life, the idea has become popular that only an expert can be expected to identify animals. This unfortunate attitude has discouraged many a promising beginner from attempting field work. We do not for one moment deny that the final verification, in case of rare or peculiar animals or in scientific studies, should be made by an authority on each group. We do feel, however, that the more common animals can be identified with reasonable accuracy by any interested person who is willing to follow up the use of keys, such as are given here, with a careful checking of the descriptions given in the references listed. The present work is designed not to replace, but rather to serve as an introduction to, the painstaking and detailed works of our zoologists.

The type of key used is one that we have found, after much experimentation with students and long-suffering friends, to be the easiest to operate, especially if one is holding a squirming animal in one hand meanwhile. Wherever possible external and readily visible identification characters have been used. For the finer details of classification a complete study of the animal—external and internal anatomy and even physiology— is necessary, but this book is intended for the use of those who are not yet expert zoologists. It is also intended to serve as a field manual, where dissection facilities are seldom available. Line drawings are included as the simplest way of picturing the terms and characters used in the keys and to give the amateur an idea of the likenesses and diversity to be found in each group.

Not every species, or even every genus, can be included within the limits of this book. The rarer forms not included will usually key to the most nearly related of the included forms, and consultation of the literature will usually clear up the difficulty. For groups about which a great deal of information is readily available, such as the birds and insects, only general treatments have been considered necessary. Some groups, such as the Ostracods and the smaller water Turbellaria, which are minute or require the knowledge or dissection of certain parts beyond the skill of the amateur, are carried only to the group or to the most common families or genera.

Names of classes, orders and other large taxonomic groups have not been used in most cases in the keys, where animals are keyed to genus and species. Zoologists are not in perfect agreement as to the application of these terms, since the rules of the International Committee on Zoological Nomenclature cover only family, genus and species. Also we feel that the main outlines of taxonomy and the complicated foundations of anatomy and physiology upon which they rest can best be learned from standard zoological textbooks and are likely to be confusing if inserted in the keys, especially since a number of the animals included do not possess all the characters regarded as typical for the groups in which they are placed. To acquaint the student with the general form of such grouping, to make the reference books more easily consulted, and to give him some preliminary benefits of the use of the larger groups in grasping the idea of relationships, we have given, at the end of the discussion in each chapter, an annotated outline of the general scheme of classification of the group. The more readily observed characters which, taken in combination, distinguish the native forms in these large groups, have been listed. Wherever feasible, family names have been included in the keys.

Many scientific names have been changed within the last quarter century, due in part to our better knowledge of animal relationships and in part to the researches among the long ignored or overlooked writings of early American naturalists, who now receive long delayed credit for the application of many scientific names. We have endeavored, in most cases, to use as first choice the scientific names given in a recent check list for each group. In cases where another name is still in general use it is given as second choice, except where otherwise noted, and also the synonym or synonyms are given that are most likely to have been used as the scientific name or names in the available literature.

A complete list of the publications consulted in compiling these keys would double the size of the book, so we must limit ourselves to a general grateful acknowledgement to all who have worked on the classification of American animals, with a special vote of thanks to those whose careful and critical studies in the compilation of check lists award credit where it is due and help to stabilize the use of scientific names. We are also greatly indebted to museums, friends and collectors who have made it possible for us in a great many cases to check the keys with actual specimens, either living or preserved.

We fully realize that some errors may have crept into this book, but we trust that the good outweighs the bad and that our efforts may be of some aid in bringing about a greater knowledge, and consequently a greater appreciation, of our wild animal life.

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INTRODUCTION

CHAPTER 1.

The average course in general Zoology uses marine animals for many of its type forms, so that the student gets the impression that only at the sea-shore can one study animal life in any abundance. As a matter of fact, the land and fresh-water animals include members of all the major groups or phyla of animals except the Brachiopods, Ctenophores and Echinoderms, which are exclusively marine. Brachiopods and Echinoderms are abundant in the limestone regions of our country as fossil remains, indicating that these areas were formerly ocean floors. Since the majority of our population lives away from the coast most of the time, some knowledge of and interest in inland animals seem highly desirable.

From ancient times man has been interested in naming animals. Aristotle, who lived about 350 B. C., appears to have known about five hundred animals by name. Linnaeus, who started our present system of nomenclature and who, living from 1707 to 1778, had the advantage of receiving many specimens from America, recorded the names of over five thousand. Today we recognize several hundred thousand species of animals, and more are continually being named.

Various systems of nomenclature have been proposed at different times, but a modification of that proposed by Linnaeus, being most flexible and adaptable to our modern ideas of the relationship of all living things, has been universally adopted. We now divide the animals into large groups called *Phyla*. Each *Phylum* is, in turn, divided into *Classes*, each *Class* into *Orders*, each *Order* into *Families*, each *Family* into *Genera*, and each *Genus* into *Species*. Linnaeus' great inspiration was to use the Latinized name of genus and species as the general scientific name of each animal, thus enabling the scientist to learn one name instead of a different common name in each language for each animal. So now to American, Russian and Japanese alike the name of man is *Homo sapiens*, the dog *Canis familiaris*, and so on. This scientific name was intended to be a description in itself, the name of the genus being a noun and the name of the species usually an adjective.

The student of Taxonomy or Classification is at first likely to be puzzled by the lack of agreement among different writers as to the major groupings. The early scheme of classification was merely to establish a convenient catalogue for ready reference. The modern idea is that the system of classification should also express the degrees of relationship existing between the various animals. Scientists, like laymen, often disagree as to the interpretation of evidence and therefore do not wholly agree on taxonomic groupings.

In order to keep the system of definite scientific names workable, the International Zoological Congress has established (1889 to the present) a set of rules governing the names of species, genera and families of animals. Any question concerning the proper use of these names is referred to a committee of this Congress. The most important rule established by the code is the so-called *Law of Priority*. The animal names used in the tenth edition of Linnaeus' *Systema Naturae* (1758) are accepted as the starting point. Any animal not therein described is called by the name first applied to it since, provided the describer followed the Linnaean system and published the name and description in an acceptable manner. Unfortunately many of the early scientists did not have access to the publications of others and some of them made their descriptions quite vague, so that frequently several names have been applied to the same animal. In that case the first scientific name properly given is accepted as the true scientific name, the later ones being called synonyms.

A few other rules should be kept in mind. The name of the genus is always capitalized. In animal names, although not in plant names, the name of the species should never be capitalized. A name once used as the generic name of an animal must never be used for any other animal. The latter regulation does not apply to the names of species.

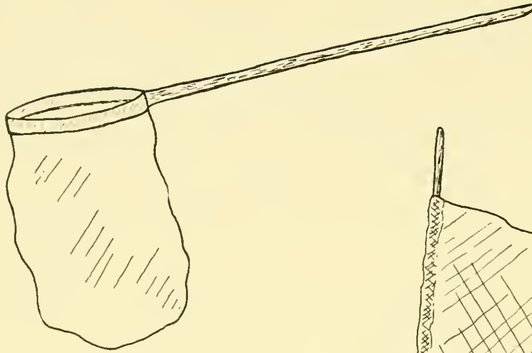
In order to enable one to refer to the original description and to check on errors, the name of the describer (called the author) is frequently written after the scientific name without intervening punctuation, as *Homo sapiens* Linnaeus. If for any reason it has been necessary to change the generic name, the name of the author of the species is bracketed. Thus the clam originally described as *Unio ovata* Say is now known as *Lampsilis ovata* (Say). Occasionally one finds three names instead of two, as *Microtus montanus arizonensis* Bailey. This means that the species has been further subdivided into subspecies, one of which, *arizonensis,* was first properly named and described by Bailey.

Identification is not always easy. Our divisions into phyla, classes and orders are arbitrary and each group includes a number of animals that do not possess all the structures regarded as characteristic of that group. Among the microscopic organisms there are several, such as *Euglena* and *Volvox,* that cannot be definitely assigned to the animal or to the plant kingdom. Many colonial protozoans can be told only with difficulty from higher forms, the usual distinction being that in the protozoan colony there is no specialization among the somatic or body cells, such specialization being the rule in the bodies of the higher animals. In our pond life the small annelid worms and the larvae of insects look much alike, the presence of distinct mouth parts and of a definite head usually distinguishing the latter. Even some vertebrates may be confused with invertebrates at first sight. Some of the degenerate, burrowing snakes and lizards have a strong superficial resemblance to earthworms. One may judge of the confusion that exists, even in the vertebrates, when he finds that one salamander is commonly called the Congo Snake and another the Mud Eel, and that one of the legless lizards is known as the Glass Snake while another lizard masquerades as an amphibian under the names of Horned Frog and Horned Toad. The keys accompanying this chapter are designed to direct the student to succeeding chapters for further identification. The associated plates illustrate forms that are not readily distinguished or assigned to their proper groupings.

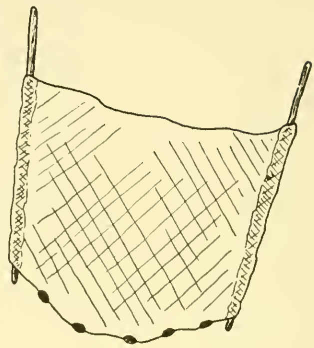
In the keys two alternatives, definitely contrasting, are offered at once, so that the characters can be quickly weighed one against the other and the decision made without any turning of pages. At the end of the choice taken is given the number of the next set of alternatives to be considered, and so on, until, instead of a number, there appears the scientific name of an animal. The fact of individual variation must be kept in mind in any attempt at identification. Between such extremes as albinism and melanism, giantism and dwarfism, there is a wide range. The keys must naturally be based on normal, adult, average or typical specimens. Whenever possible, therefore, several animals of the kind to be identified should be examined or, if only one specimen is available, the possibility of its being somewhat abnormal or immature should be considered.

Following each key is a list of references, one or more of which the reader should then consult in order to verify his identification. This list does not begin to include all the works upon the group but merely those that the author believes will be most useful in aiding in the verification of the name. Check lists of the various groups of animals known to occur within the local area are often available from state or city museums, state natural history surveys or state academies of science. If these cannot be obtained, there are still several invaluable periodicals where such lists, at least of the vertebrates, are often published. Chief among these are *Copeia* for fishes, amphibians and reptiles, *The Auk* and *The Audubon Magazine* (formerly *Bird-Lore*) for birds and *The Journal of Mammalogy* for mammals. These lists are very useful in indicating which animals may be expected in a given locality and should be consulted wherever it is possible.

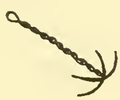
Protozoans, rotifers, small crustaceans and other minute, free-floating, aquatic forms constitute a group of organisms known as *plankton*. For identification of these and other minute creatures, a microscope is necessary. Since both size and motion appear greatly magnified under the microscope, some method of slowing down the living animals while they are being examined is desirable. A very weak solution of glycerine in water may be substituted for the drop of plain water in which the creatures are ordinarily mounted for examination. Much use should be made of lighting adjustments. For



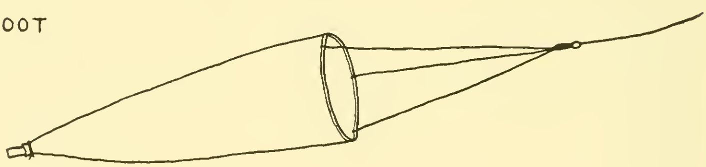
SWEEP NET



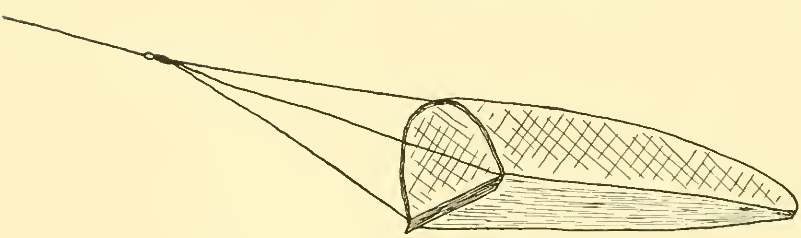
ONE-MAN SEINE



CROWFOOT



PLANKTON NET



DREDGE NET

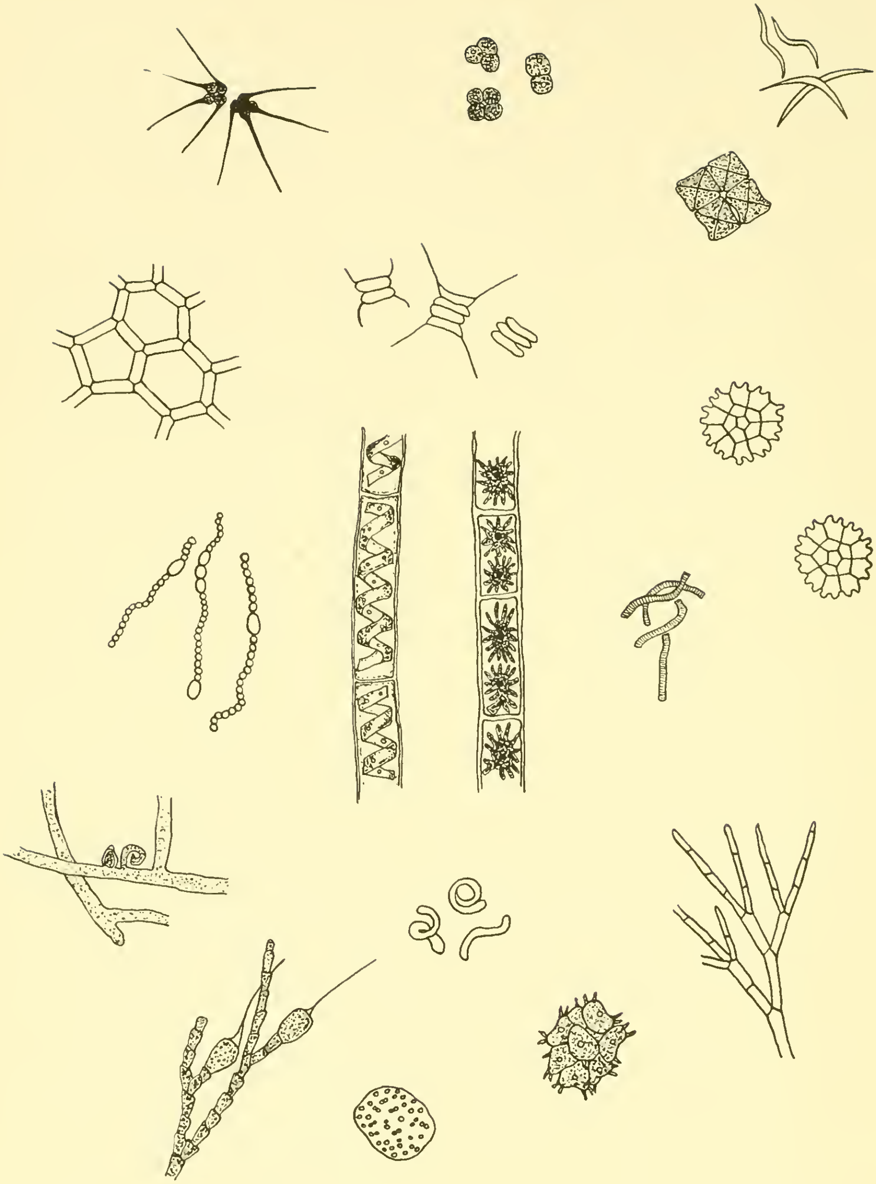
SOME COLLECTING EQUIPMENT

example, when the microscope mirror is adjusted for full brightness and the diaphragm is wide open, such transparent creatures as *Amoeba* can scarcely be distinguished, but with the light much decreased they show plainly. Frequently an additional view, helpful in showing the type of motion, may be obtained by cutting off all light from below and viewing the animals by light thrown directly on them from above. Very weak solutions of iodine or India ink often make locomotive structures of minute organisms more clearly visible under the microscope.

Collecting methods vary with the season and the kinds of animals sought. For collecting plankton and small aquatic organisms in general, a plankton net is the best piece of equipment. This consists of a cone of silk about two feet long, with the large, open end supported by a wire hoop to which a cord bridle is attached, and with the small opening in the apex of the cone fitted with a small vial, usually of about an eight dram size. In use, ten feet or more of attached cord are unwound, a little water dipped into the net to give it weight, and the net swung out as far as possible into the pond, the cord being allowed to slide freely through the fingers until the end is reached. The net is then pulled slowly but steadily back to the operator and held upright until the water has drained out through the silk, leaving the small organisms concentrated in the vial, from which they can be poured into a larger receiving bottle. The commercial plankton nets are made of silk bolting cloth, various sizes of mesh being available. Although such nets are essential for scientific investigation, the average collector will find a home-made one of ordinary silk much more economical and quite efficient. A swivel such as fishermen use on bait-casting lines may be attached near the bridle to add to the smoothness of operation.

Other minute organisms that cannot ordinarily be collected with the plankton net may be obtained by gathering up with a pipette some of the brown ooze that often covers the beds of ponds and slow streams. Scrapings from submerged rocks and the under sides of water lily pads are often full of interesting organisms. Bird baths in which the water is kept constant often reveal a surprising fauna and flora, some introduced as windblown dust and some brought in on the feet of birds.

Larger organisms can be collected with the aid of small, hand, kitchen strainers, which can be obtained with fine or coarse meshes. If the animals are desired in larger quantities, they can be collected from the ponds quite easily with the aid of a bucket. If the collector will wade into a bed of submerged vegetation and grab up a mass of it, transferring it to the bucket without lifting it from the water any more than is necessary, he can then swirl it around, washer-woman fashion, and throw it aside, usually leaving a host of insect larvae, small crustaceans, snails and other animals at the bottom of the bucket. This method usually gives better results than the use of the common dip-net.



ALGAE - MUCH ENLARGED

SMALL AQUATIC PLANTS

Still another method, if space and neighbors permit, is to bring in a large mass of vegetation, gathered without disturbing it much, and put it into a container with just enough water to cover it. In a day or so the vegetation will start to decay and the animal population will seek the surface in search of oxygen. *Hydra* may often be collected by the hundred by this method.

For larger aquatic animals the dip-net, seine and all the apparatus of the fisherman may be used. Sections of minnow seine make excellent material for constructing dip-nets. This material may be purchased by the yard. A one-man seine from two to three feet long and one and one-half to two feet high has the advantage of being small enough so that the operator can take a pole in each hand and push the net before him through the water. For fresh-water clams, a rake or a modification of the commercial "crowfoot" may be used to advantage. Some form of dredge may be used for bottom fauna, if the collecting is done from a boat. Before resorting to seines or traps, one should consult the game laws carefully, as some states have rigid restrictions.

The smaller land animals are usually to be found in moist or sheltered locations, such as in woodlands under fallen logs or loose bark. Snails, insects and many other invertebrates are often collected most easily after a rain. Then the snails leave their hiding places and insects are less likely to seek safety in flight. For ecological studies dealing especially with terrestrial insects, the piece of collecting equipment most frequently used is the sweep net, a fine, light-weight net designed for use among bushes, grass and other low vegetation.

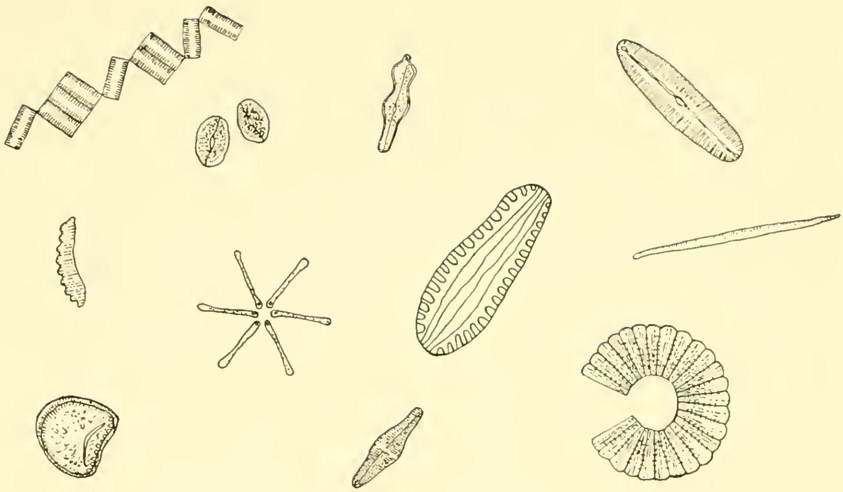
Most of the vertebrate animals are either naturally crepuscular or nocturnal, or else have had such habits forced upon them by man. Years ago market hunters realized this and resorted to jack-lighting or hunting the animals with the aid of artificial light, finding that even the large game animals are then much less timid than by day. Fortunately the tendency today is to give an animal a fair chance, and such means of hunting are outlawed, but the student of animal life may well adopt this method for less destructive purposes. Many fish, most amphibians, and many reptiles and mammals are active and may be watched after dark, showing little of their daytime timidity. Several naturalists have taken advantage of nocturnal habits to obtain unusual flashlight photographs of our wild animals.

For a closer study and appreciation of the lives of the small animals, the maintaining of aquaria and terraria is recommended. For an aquarium a glass container or even a water-tight wooden bucket or tub may be used. A metal tank is likely to give off injurious materials to the water, unless thoroughly seasoned. The shape of the container should be such that there is plenty of water surface exposed to the air for the absorption of oxygen. This requirement rules out the fish globes of past popularity. If a choice is possible, the aquarium should be such that it will contain a rectangular volume of water as high as wide and twice as long. For a permanent set-up an inch or more of good garden soil should be tamped firmly into the bottom and covered with an inch-deep layer of sand that has been washed in several changes of water until it is free from sediment. Then a sheet of paper may be laid on the sand, the water slowly added, and the paper removed. This method of adding water serves to keep the sand and soil from being disturbed. Filtered pond water is best, if available. City water that contains chlorine should be avoided, if possible, or at least allowed to stand in the open for several days before it is used. Plants may next be set out. *Elodea* is excellent, if kept trimmed. *Vallisneria*, the Ribbon Grass, is also very good. Then, most important of all, the planted aquarium should be allowed to stand for several days before any animals are introduced. If the plants start to grow and the water remains clear, all is well. If not, the water should be gently siphoned off and more added. Animals should not be crowded. If too many are introduced, they damage each other and the plants, and the water becomes cloudy. Food not cleaned up within an hour should be removed. If the aquarium is set up properly and attains a balanced condition, it should remain clear and never need changing. Enough water should be added from time to time to make up for that lost through evaporation. If the water becomes green, it is receiving too much light, and unicellular green algae are developing. These algae do not harm the animal inhabitants of the aquarium, but do reduce the visibility. To correct this condition the light should be reduced and a small clam put in for a week or two to filter out and eat the algae.

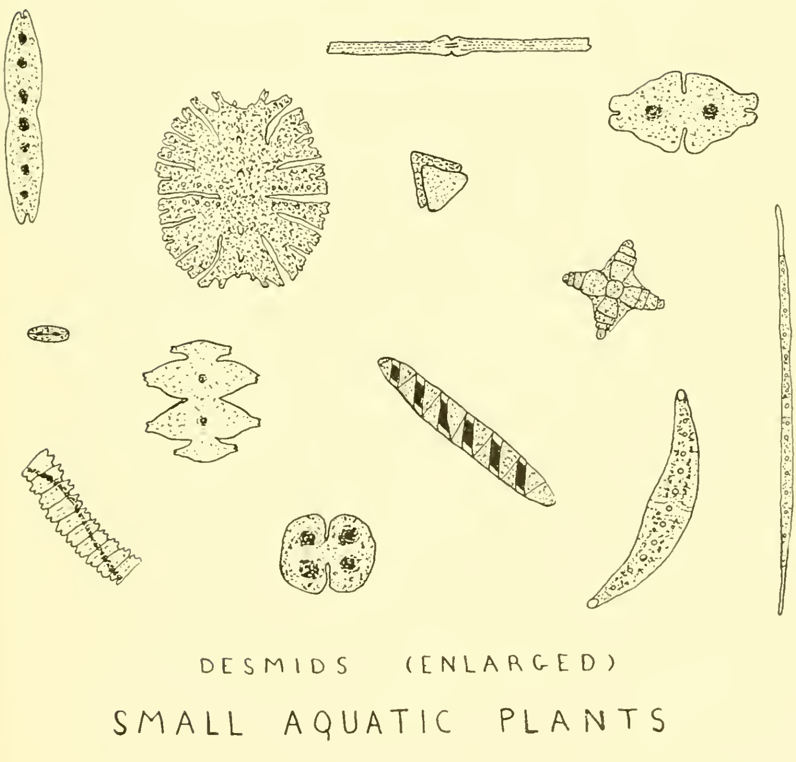
The terrarium is for land animals or those that spend most of their time on the banks of ponds or streams. Turtles, frogs, some salamanders, lizards and small snakes do well in terraria. A large, old aquarium, discarded because of leaks or cracked glass, can often be utilized in this fashion. A shallow dish of water is set within, and the rest of the floor covered with liverworts or moss. A glass cover, slightly raised by toothpicks or matches, should be used. Such a greenhouse will flourish for months with little attention except that necessary for its animal occupants, although an occasional "lawn mowing" with a pair of shears may be necessary.

A combination of aquarium and terrarium is possible in a long container. One end can be raised so that a "shore line" occurs in the middle of the tank, and a little sphagnum or water-moss put along this edge. Crayfishes, hellgrammites, turtles, most salamanders and many other creatures thrive in such an environment. Small worms, snails, and *Drosophila* or fruit flies and other insects make acceptable food for most of these animals. Such a terrarium should also be kept covered.

For larger animals, particularly birds and mammals, various types of cages are available. A caged animal should always be given plenty of room



DIATOMS (ENLARGED)



DESMIDS (ENLARGED)

SMALL AQUATIC PLANTS

and an opportunity for exercise. The small roadside cages used for foxes, bears and other animals displayed for advertising purposes are pitifully inadequate and should be condemned.

All those interested in wild animals should consider it their duty to do all that they can to protect and conserve them. Unfortunately most of the zoological training given in our schools and colleges has been directed almost entirely along the lines of preparation for medical work and very little towards appreciation of living animals. Lack of time and equipment has generally prevented field trips and the maintenance of living animals other than experimental rats and guinea-pigs. Our libraries contain many books describing the details of dissection and minute anatomy, but few concerning the life histories and habits of our wild animals. After all, it is life itself in which we are primarily interested. Too often we find ourselves in the position of the child who has taken his mechanical toy apart to see what makes it work. We can describe in great detail the structure of the song bird, its trachea, its syrinx or voice box and all its internal structure, but we are as far from explaining its song as ever. This is not a condemnation of the work done, but rather a call to additional study before it is too late and many of these animals have gone from the earth forever. It is urged that field excursions be regarded more as observation trips than as collecting trips, that the live animal be considered more valuable than its preserved skin or carcass, and that any unusual animal should not be feared because it is unknown or shot as a trophy because of its rarity, but regarded as presenting an opportunity to study another manifestation of that peculiar something we call life.

The hunter and trapper have received more than their share of blame for the decrease in number and species of our wild animals. By far the greatest factor in the decline has been the destruction of breeding grounds. All over the country lakes and marshes have been drained, rivers dammed and polluted, streams straightened, forests and groves destroyed, and land useless for agriculture used for grazing until all vegetation is destroyed. Coming down to details within the control of the individual, thickets have been reduced to hedges, hedges replaced by wire fences, hollow tree limbs so sought by birds, squirrels, bats and other animals as homes or refuges filled with cement or removed, tangles of sprouts around the bases of lilac and syringa bushes carefully trimmed, snakes killed on sight "because we don't like them", frogs and toads and their eggs promptly removed from ponds in garden and park.

Another less powerful but never-the-less important factor in reducing our wild life has been the over-protection of a few animals and the ill-advised introduction of foreign forms. Even in this day of enlightenment many people still seem to retain the ancient Egyptian reverence for the cat, allowing it to reproduce as fast as it can and then abandoning the kittens by the roadside to die a miserable death or to revert to a semi-wild condition at the expense of native birds and mammals. Where there are summer cottages these semi-wild cats are common, the kittens having been brought in as pets at the beginning of the vacation season and abandoned at its close. So serious is this condition that at least one state has passed a law making it a punishable offense to abandon a cat.

Another marked case of over-protection is that of the house wren. Fully ninety per cent of the bird boxes put up are designed for or used by wrens. This innocent-looking little bird forestalls competition by visiting the nests of other birds within a wide area and puncturing their eggs. The house sparrow receives the blame but, even if this action of the wren had not been repeatedly observed and reported in bird magazines, an inspection of the punctures and of the beaks of wren and sparrow would exonerate the latter of that particular crime.

The house sparrow and the starling are both examples of unfortunate introductions that have increased the competition for our native birds. The carp is another exotic of doubtful value, unless the introducers anticipated the extreme pollution of our rivers to the point where only an extremely hardy fish could survive.

Our National Parks have set excellent examples of what can be done to protect and tame our wild animals, but these parks should not be their only refuge. It is perhaps encouraging to note that almost all our errors in dealing with wild life have been due to ignorance rather than to willful action. It is sincerely hoped that interest in and knowledge of animals will steadily increase, and that sensible conservation measures, well supported by an informed public, may be generally adopted.

GENERAL OUTLINE OF CLASSIFICATION OF NATIVE LAND AND FRESH-WATER ANIMALS

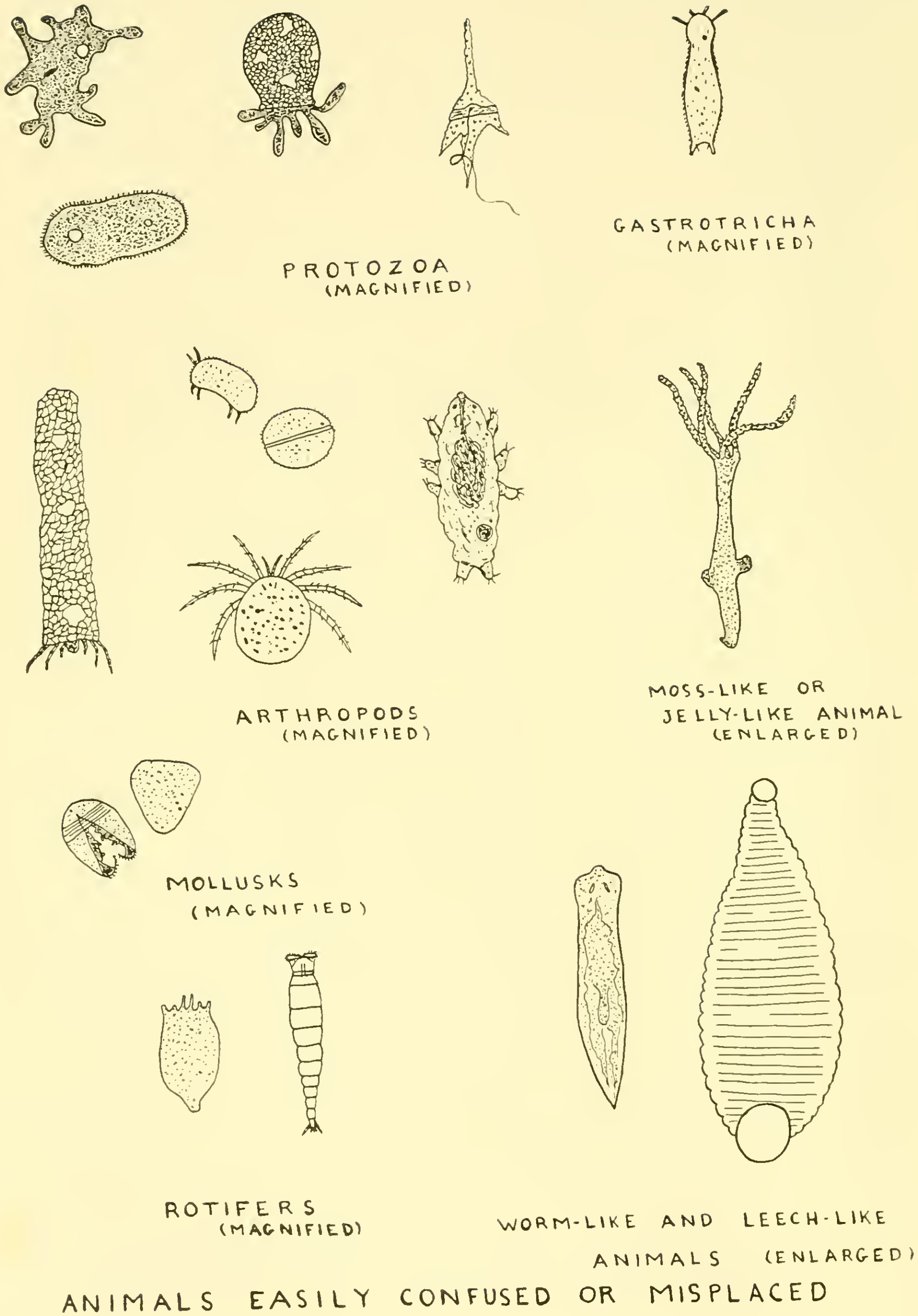
Invertebrates

Phylum PROTOZOA

One-celled or with somatic cells all of the same type grouped into colonies

Phylum PORIFERA

Usually colonial; body wall with a simple or complex arrangement of canals between a central or gastral cavity and the outside; two cellular body layers present, with a middle, undifferentiated layer containing skeletal fibers or spicules



ANIMALS EASILY CONFUSED OR MISPLACED

Phylum COELENTERATA

Individual or colonial forms; two cellular body layers present; radially symmetrical; digestive tract sac-like; usually with tentacles; with stinging cells or nematocysts

Phylum PLATYHELMINTHES

Bilaterally symmetrical, dorso-ventrally flattened, unsegmented worms; no coelom; digestive tract sac-like; with cilia

Phylum NEMATHELMINTHES

Cylindrical, unsegmented worms: without cilia

Phylum ROTATORIA

Usually with a ciliated disc anteriorly; with mastax or internal jaws; with coelom

Phylum BRYOZOA

Colonial; with tentacles on a ridge around the mouth; digestive tract U-shaped; with coelom

Phylum ANNELIDA

Segmented worms; with setae in the body wall or with a sucking disc on the posterior end of the body; with coelom

Phylum MOLLUSCA

Body soft, unsegmented; usually with a shell; sometimes with tentacles

Phylum ARTHROPODA

Body segmented; usually with a chitinous exoskeleton; appendages paired, jointed

Invertebrates of uncertain position

NEMERTEA

Unsegmented; with a long, eversible proboscis; digestive tract tubular; no coelom (Often grouped with Phylum *Platyhelminthes*)

GASTROTRICHA

Unsegmented; somewhat flattened dorso-ventrally; ciliated below; digestive tract tubular; with coelom (Often paired with the *Rotatoria* under Phylum *Trochelminthes*)

TARDIGRADA

With fused segments; appendages paired, unsegmented; (Grouped with Phylum *Arthropoda* in this book)

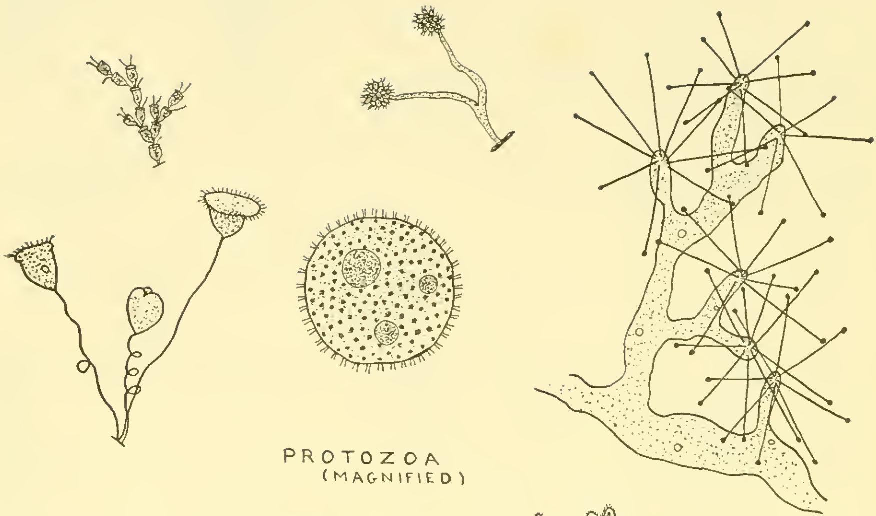
Vertebrates

Phylum CHORDATA

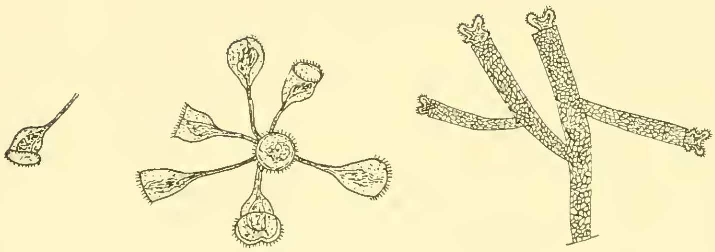
Possessing, at some stage in development, a notochord or backbone, pharyngeal gills or lungs, and a dorsal, tubular nervous system

Class CYCLOSTOMATA

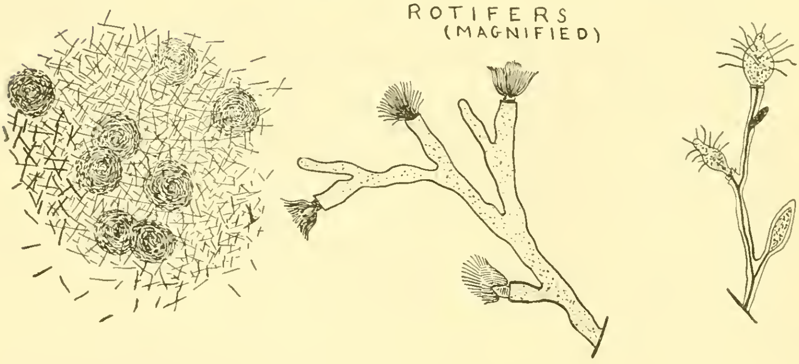
Mouth round, without jaws; no bones; no paired appendages; cold-blooded



PROTOZOA
(MAGNIFIED)



ROTIFERS
(MAGNIFIED)



MOSS-LIKE AND JELLY-LIKE ANIMALS
(MAGNIFIED)

ANIMALS EASILY CONFUSED OR MISPLACED

Class PISCES

With paired fins; with or without scales; one occipital condyle; cold-blooded

Class AMPHIBIA

Usually with one or two pairs of limbs; without scales; with two occipital condyles; cold-blooded

Class REPTILIA

With or without limbs; with scales; with one occipital condyle; cold-blooded

Class AVES

Fore limbs modified to form wings; with feathers; with one occipital condyle; warm-blooded

Class MAMMALIA

With one or two pairs of limbs; with hair; with mammae; with two occipital condyles; warm-blooded

KEY TO THE MINUTE AQUATIC ANIMALS

1. One-celled or acellular animals, either separate or grouped together in colonies; no specialization of body cells of colonial forms, which are usually spherical, disc-shaped or grouped at the end of a stem
   Protozoa (Chapter 2)

   Body made up of a number of cells, with some of the body cells differing from others; usually with internal organs visible inside the body wall 2.
2. Animal partially or wholly enclosed within a shell 3.

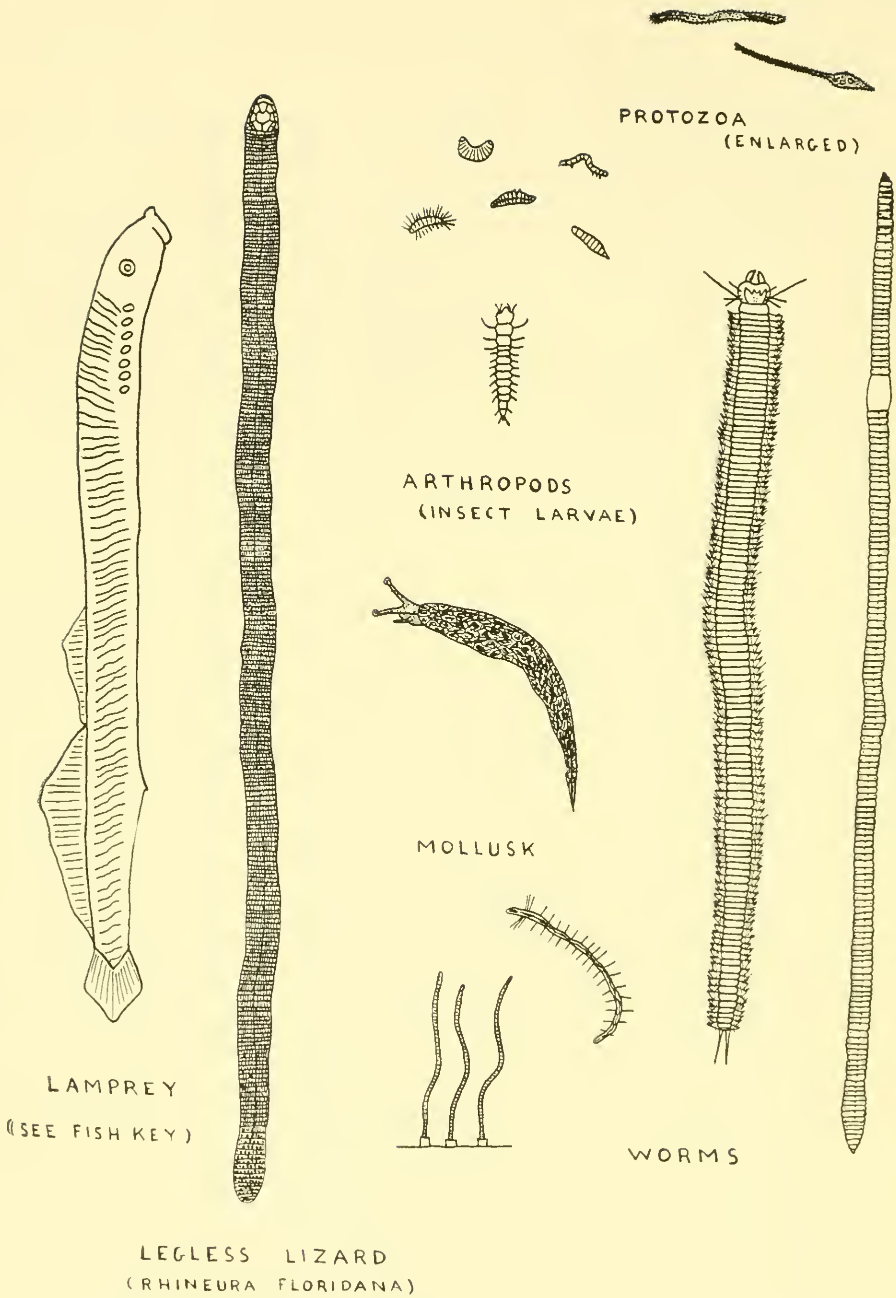
   No shell; animal sometimes living in a tube 4.
3. Body soft, without legs
   Mollusks (Chapter 6)

   With paired appendages, which may be completely withdrawn within the shell, in some forms
   Arthropods (Chapter 7)
4. With paired appendages
   Arthropods (Chapter 7)

   No paired appendages; sometimes with setae or tufts of bristles along the sides 5.
5. Body segmented (segments sometimes evident only on the under side) 6.

   Body unsegmented 8.
6. With a definite head, often darker than the body, and usually with external biting or sucking mouth parts
   Arthropods, Insect Larvae (Chapter 7)

   Not so 7.



ANIMALS EASILY CONFUSED OR MISPLACED

7. Body soft and transparent, with a pair of jaws working within the body; usually but not always with one or more rings of cilia on the front end; sometimes colonial

Rotifers (Chapter 4)

Body worm-like; without visible internal jaws; with or without bristles along the sides of the body

Worm-like or Leech-like Animals, Annelids (Chapter 5)

8. With a ring of tentacles

Moss-like or Jelly-like Animals (Chapter 3)

No tentacles, but often with bristles or cilia 9.

9. With tufts of bristles or cilia or with one or more rings of cilia in the area of the mouth; sometimes colonial

Rotifers and Gastrotricha (Chapter 4)

Not so

Worm-like and Leech-like Animals (other than Annelids) (Chapter 5)

KEY TO THE NON-MICROSCOPIC LAND AND FRESH-WATER ANIMALS

1. With legs 2.

No legs; sometimes with setae or tufts of bristles along the sides 8.

2. With fur, hair or feathers 3.

No fur, hair or feathers 4.

3. With hair or fur; with two pairs of legs, or sometimes with the fore limbs modified to form wings

Mammals (Chapter 15)

With feathers; with one pair of legs and one pair of wings

Birds (Chapter 14)

4. Animals without a backbone; usually with more than two pairs of legs; almost always with antennae or with external biting or sucking mouth appendages; often with wings

Arthropods (Chapter 7)

With a backbone; with one or two pairs of legs; no external biting or sucking mouth appendages; skin usually slimy or with scales 5.

5. With the skin slimy, unscaled; no external ear openings 6.

With a scaled skin or with external ear openings 7.

6. Body usually slender and with a tail; young are usually with gills

Salamanders (Chapter 9)

Body fat, without a tail in the adult, except in the male of one species; the young or tadpoles have tails, very fat bodies, and no or one or two pairs of legs each

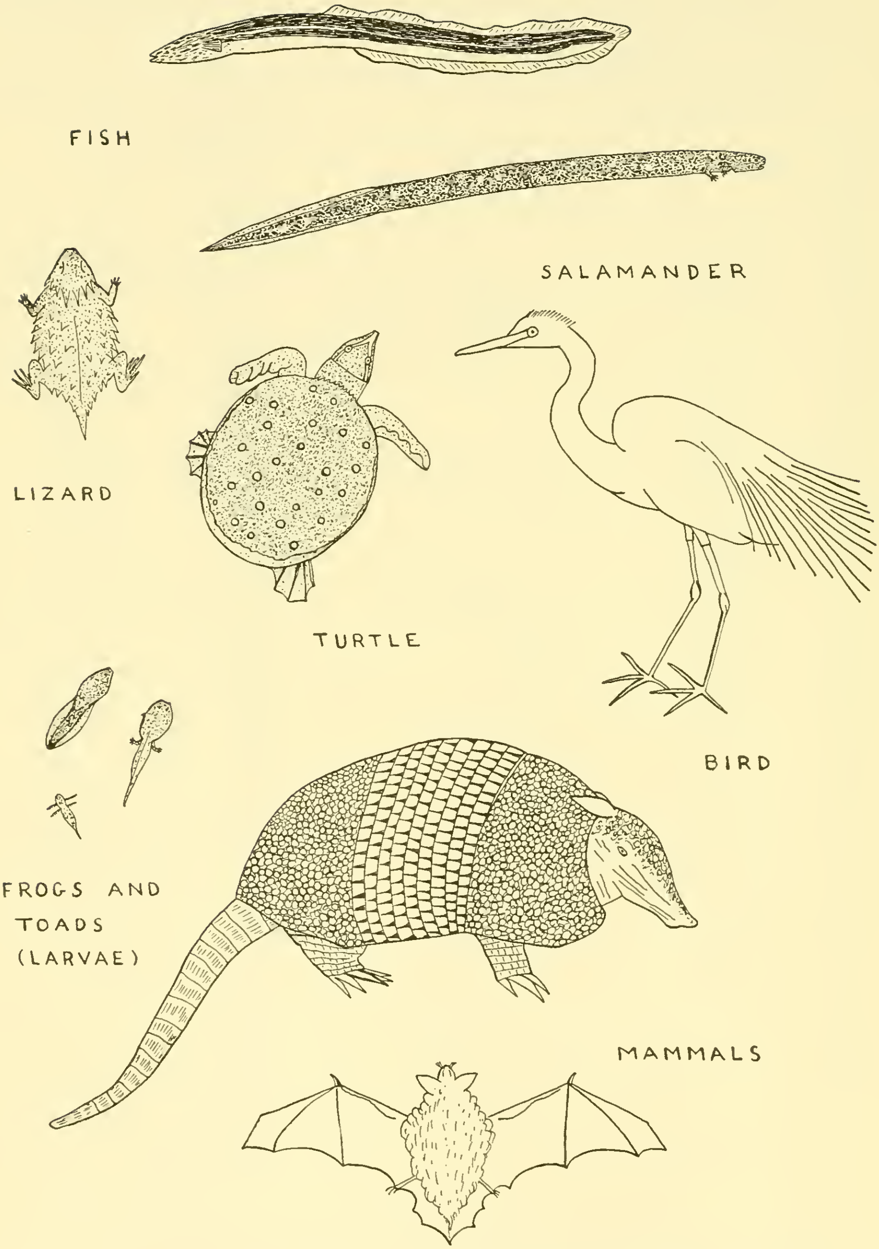
Frogs and Toads (Chapter 10)

7. With a leathery or horny shell

Turtles (Chapter 13)

No shell

Lizards (Chapter 11)



ANIMALS EASILY CONFUSED OR MISPLACED

8. Soft-bodied animals enclosed or partially enclosed in a shell
Mollusks (Chapter 6)
Not so 9.

9. Colonial animals, usually appearing moss-like or jelly-like
Moss-like and Jelly-like Animals (Chapter 3)
Single individuals 10.

10. With fins or with a wide fold of skin forming a fin-like tail 11.
Without fins or a fin-like tail 12.

11. No gill openings on sides of head; head and body so closely joined as to be oval; no side fins
Frog and Toad Larvae, Tadpoles (Chapter 10)
With one or more gill openings present on each side of the head; body lengthened; side fins present in most cases
Fishes and Lampreys (Chapter 8)

12. With definite scales or plates on top of the head and usually on the body
Snakes and Legless Lizards (Chapter 12)
No scales 13.

13. Body segmented (segments sometimes evident only on the under side) 14.
Body unsegmented 15.

14. With a definite head, often darker than the body; usually with external biting or sucking mouth appendages
Arthropods, Insect Larvae (Chapter 7)
Head not readily distinguishable; no such mouth appendages (except in one large semi-marine worm)
Worm-like and Leech-like Animals, Annelids (Chapter 5)

15. Without tentacles; no breathing pore on the side
Worm-like and Leech-like Animals (other than Annelids) (Chapter 5)
With tentacles; with or without a breathing pore on the side 16.

16. With a ring of tentacles around the body; no breathing pore; found in water
Moss-like and Jelly-like Animals, Coelenterates (Chapter 3)
With two pairs of tentacles on the head and a breathing pore on one side; found in moist places on land, not in water
Mollusks, Slugs (Chapter 6)

KEY TO THE PRINCIPAL LARGE GROUPS OF VERTEBRATES, BASED ON SKULL CHARACTERS

1. Bones overlapping and covered with striations radiating from the center of each bone
Fish
Bones more or less dovetailed or with sutures (junctions) not evident 2.

2. Two occipital condyles (knobs on either side of the large opening on back of skull, for attachment of the first segment of the backbone) 3.
One occipital condyle, usually below the large rear opening 6.

3. Skull high—height at least half the width; with a bony palate before and partly underlying the floor of the brain case
Mammals (See chapter 15)
Skull flat—height not more than one-fifth of the width; with a bottle- or dagger-shaped bone forming a large part of the under side
Amphibia 4.

4. With a gap between the end of the upper jaw and side of cranium, or with a short row of teeth in the center front of a complete row on upper jaw; processes on which the lower jaw is hung slanting forward
Salamanders
With a bar joining the end of the upper jaw to the side of the cranium; processes on which the lower jaw is hung slanting backward 5.

5. With teeth on the upper jaw
Frogs and Spadefoot Toads
No teeth on the upper jaw
Toads

6. Brain case almost spherical, the bones fused together so that their sutures are not visible; orbits (eye-sockets) very large, about one-third of the total length of skull; jaws elongated to form a beak
Birds
Brain case flattened or angular; sutures usually visible; orbits seldom more than one-fifth of the total length of skull; jaws not beak-like, or else with a sharp ridge on back of skull 7.

7. No evidences of teeth; bones of skull, except lower jaw, apparently all joined immovably together; with a sharp central crest on back of top of head
Turtles
Teeth present; no prominent crest on back of skull 8.

8. Skull long, wide and flat; bones solidly joined; teeth peg-like, set in sockets
Alligator
Skull not especially long, wide and flat; bones suspending the lower jaw somewhat movable or hinged to others; teeth needle-like, fused to the top of the inner edge of jaw bone 9.

9. Bones of brain case solidly joined, but almost all others hinged; usually with two rows of upper teeth, the inner row as long and well developed as the outer row
Snakes
Bones suspending lower jaw hinged, but the others fixed in position; a small opening usually present in the top center of the brain case
Lizards

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PROTOZOA

Chapter 2

Protozoa abound in practically every situation where life is possible but, on account of their minute size, they seldom come to our attention. Only the largest of them are visible without the aid of a lens. Consequently they lived almost unnoticed until about 1675, when the early microscopists made for themselves tiny glass drops which served them as lenses, fixed these in adjustable frames, and sought to examine every minute object available. Since then many arguments have followed as to the structure of these little animals. Some investigators have described vital organs within these Protozoa while others, finding no cell walls within the animals, object to the terms used for the multicellular forms. Some scientists regard the Protozoa as the simplest forms of animal life and so place them as the first and "lowest" group of animals. Other scientists, marvelling at the many functions performed by the tiny creatures and the specialization they show, contend that instead of corresponding to one of the body cells of the other animals, as the term "unicellular" implies, we should rather regard a protozoan as corresponding to the whole of a higher animal, but without the subdivision into cells, and therefore apply the term "acellular", meaning without cells. Along the same lines there is a tendency to regard the group of *Protozoa* not as one of the twelve or more phyla but as a major division of the animal kingdom, parallel to all the other animals, which are then called *Metazoa.*

Few of the common Protozoa attain enough size to attract one's attention, except under the microscope. The largest of the celebrated amoebas, when extended, may reach a diameter of one one-hundredth of an inch. *Spirostomum,* which at certain seasons is extremely abundant in garden lily ponds, is a giant among the common Protozoa, as it reaches a length of one-tenth of an inch. *Paramecium,* the form most studied in biological classes, is among the larger Protozoa, but it is still so small that eighty-five of them, lined up head to tail like circus elephants, would just reach across the narrow side of a postage stamp, while, if placed side by side, it would take about three hundred and forty to extend from one side of the stamp to the other.

Protozoa are classified according to their methods of locomotion. The *Amoeba* group, the *Rhizopoda* or *Sarcodina,* have the most changeable shape, usually being spherical when at rest but extending long projections, pseudopodia or false feet, when crawling or floating. Some of them, like *Arcella,* secrete vase-like outer covers or shells. Some, like *Difflugia,* go still further and accumulate sand grains or other foreign particles to supplement these shells. The animals of this group are most common in the layers of ooze or mud on the bottom of quiet ponds or swamps.

Another group, the *Ciliata* or *Infusoria,* of which *Paramecium* may be regarded as typical, have a fairly constant body shape and propel themselves by means of countless hair-like extensions of protoplasm called "cilia", from the Latin word for eyelash. These cilia, unlike pseudopodia, are always extended and serve as oars to row the animal through the water. Although the details of the arrangement of the cilia are hard to make out, yet, as a general rule, if the animal moves at a fairly even gait, it is probable that the cilia are almost all of the same length, while, if the gait is jerky and irregular, the cilia are usually of unequal length or unevenly distributed over the body.

A third group, the *Flagellata* or *Mastigophora,* meaning the "whip-bearers", have a few, long, protoplasmic processes or flagella, instead of many short cilia. *Euglena,* the green organism that is on the border line between plant and animal, is a common example, and so is the less common but extremely beautiful colonial form, *Volvox.*

Another group, often classed as a subdivision of the *Ciliata,* is the *Suctoria.* This group includes several odd Protozoa, most of which might be confused with ciliates in their early stages and with flagellates in their more mature form. Their protoplasmic extensions from the body are neither cilia nor flagella, however, but sucking tubes, which enable them to prey on other Protozoa.

These generally accepted groups are not absolutely definite, for some intermediate forms occur. Some amoeba-like animals pass through a flagellate stage and some of the flagellates will move, especially when in the limiting confines of a drop of water on a microscope slide, with an amoeboid motion.

Many Protozoa use these characteristic structures for the intake of food as well as for locomotion. Thus the pseudopodia or false feet of the rhizopods flow around and incorporate particles of food into the bodily substance; some of the cilia of the ciliates often serve to direct food into the mouth; the flagella of flagellates may also be used to direct food toward the mouth area. The stationary *Suctoria* absorb nutriment through their sucking tubes. There is some debate whether such border animals as *Euglena* take food as do other flagellates or whether they synthesize food, as do plants, by means of the chromatophores that give them their green coloring. Probably they do both. Protozoa feed on plant or animal material, either living or dead. Many of them eat bacteria. Some of the larger forms are able to prey upon their fellow Protozoa or other microscopic animals.

The adaptation of Protozoa to environment is best demonstrated by their means of enduring hard times. Most Protozoa, when drought or other hazards threaten, eliminate all surplus moisture, thicken the outer coat, and enter into a resting condition known as encystment. The animal, now referred to as a cyst, can endure drying, freezing, or almost any other natural condition. *Paramecium,* for example, has a cyst stage in which it almost exactly resembles an angular grain of sand and may be blown as a particle of dust to a point far from its original home. Many of the Protozoa profit by this so-called resting period to divide their living substance into two, four, eight, or even more equal portions, so that, when danger is past and the environment is once more suitable for life, the wall of the cyst breaks and not one but a group of Protozoa is released. Under favorable conditions most Protozoa reproduce by dividing into two approximately equal portions, which soon round out to be complete animals, each capable of growing and repeating this process of fission. Thus the number increases in geometrical progression, the population doubling with each generation. It is sometimes said that the protozoan is potentially immortal, since the parent becomes its two offspring—and so on, indefinitely. Some ciliates at intervals each temporarily unite with another for exchange of nuclear material—a procedure known as conjugation—before fission is resumed. At times in some Protozoa another method of reproduction occurs. One individual may divide into a number of small units, and another one of the same species into a few large units. Neither a large nor a small unit can develop further by itself, but must fuse with one of the other type. The large ones are called macrogametes and are regarded as female, the small ones or microgametes as male, and so appears the beginning of sexual reproduction. Isogametes or gametes of equal size are produced by some species. Many of the invertebrates retain the habit of asexual reproduction, but the sexual method, with its possibilities of new combinations of parental characters, becomes increasingly more important in the higher forms.

STUDY OF PROTOZOA

Collecting

Protozoa large enough to be seen with an ordinary compound microscope may be found in almost any body of standing water. Many forms also occur in soil, but are less easily observed. Even garden bird-baths often prove to be good collecting spots, as many forms may be carried on the feet of birds. The scum on the surface of still ponds swarms with Protozoa and other minute animal and plant organisms. The ooze on the bottom of such ponds is also well supplied with microscopic fauna and flora.

As in all kinds of hunting, the protozoologist must be somewhat of an ecologist for successful collecting. Almost all Protozoa profit by the presence of enough vegetation to slow down the surface currents and to keep up the oxygen supply. If one is seeking the free-swimming ciliates or flagellates, he will find many kinds at or near the surface of the water or among strands of filamentous algae. Some attach themselves to leaves of submerged plants. Often what appears superficially to be a coat of fine mold or "fur" on such leaves will be revealed by the microscope to be a host of the bell animalcules, *Vorticella,* or the trumpet animalcules, *Stentor,* or similar forms. Small snail shells often carry such a collection, usually all of one species. Even such rapidly moving animals as the crayfishes and scuds furnish temporary or permanent caravans for Protozoa. Hydras very often carry one or more kinds of ciliated, commensal Protozoa. The amoeboid forms are more likely to be found on the bottom ooze or on the under sides of old water-lily leaves. Since they can survive more acid conditions than can most of the flagellates and ciliates, they can often be most easily collected in boggy or marshy ponds and cat-tail swamps.

A good method of collecting is to dip a jar into the water and push into it some of the water plants, dead and alive, without first lifting them from the water. Another method is to use a fairly large container and "wash" several handfuls of water plants in it. Many of the minute animals can thus be washed off and concentrated, most of the weed being discarded. For the larger forms a plankton net may be used, or pond water poured through a piece of silk and the "strainings" washed off into the collecting bottle. Specialized equipment, such as the plankton pump, is available for qualitative and quantitative studies.

Collections should be made at different hours of the day, and in both sunny and shaded places, as each species has its optimum of temperature and light, and a continuous movement takes place as the different forms seek the optimum conditions. Those with chlorophyll usually prefer the sunny areas, while those not green or brown avoid bright illumination.

Care and study

Material brought in from the field should be placed in shallow dishes in a fairly well lighted and cool place not in direct sunlight. Some green water plant will aid in maintaining favorable conditions but care should be taken to avoid a surplus which will rot and spoil the whole collection. If any water is added, it should not be chlorinated tap water or freshly distilled water, which is usually acid. For any aquatic animals from Protozoa to fish, it is usually advisable to "temper" the extra water by allowing it to stand for several hours in an open, non-metallic container near the aquarium or culture to which it is to be added. Large containers make fatal fluctuations in temperature less likely but, where temperature is fairly constant and it is desired to keep several collections separate, finger bowls or jelly glasses serve well and are inexpensive. Crustaceans and insect larvae should be removed, if the Protozoa are to survive.

Examinations should be made at intervals over a considerable period of time, for a succession of forms may appear, especially if the cultures are large. At first only a few ciliate or flagellate forms may be found, but two or three days later another batch of entirely different flagellates or ciliates may appear in the same container, and after a week or two, when a succession of these has died out, amoeboid forms may become numerous for several days. Finally some of the smaller metazoans, such as rotifers and annelids, displace them.

If observation of these animals under the microscope is difficult on account of their extreme activity, there are several methods of slowing them down. A small drop of sugar syrup, of glycerine, alcohol, or of one per cent solution of formaldehyde placed against the edge of the cover glass under which the animals are imprisoned will gradually seep in and slow up their activity. If cilia and flagella are hard to see, after all possible adjustments of the microscope mirror and diaphragm, a very little weak iodine solution may be allowed to work in under the cover slip and, if used in moderation, will not kill the animals until sufficient time has elapsed for close observation.

CULTURES

Many kinds of Protozoa can be grown readily in cultures. Although it takes great care and skill to grow only one kind of Protozoa and maintain them as a pure culture, the beginner will find it relatively easy to establish and maintain mixed cultures. Many and detailed are the directions given in scientific reports, but the root of the matter is that bacteria are necessary for food for many Protozoa, and the larger Protozoa often feed on their smaller relatives, so that any mixture which will develop a growth of bacteria is likely to support Protozoa. The early microscopists noted the appearance of small animals in infusions of hay, bread, and even red pepper, and called these animals *Infusoria,* a term now reserved for one group of Protozoa.

Just as each kind of Protozoa has an optimum temperature and light exposure, so each has an optimum of food concentration and an optimum of acidity or alkalinity. These optima account for the succession one finds in ponds and cultures. Unless these optima are known, it is advisable that several cultures, differing in kind and concentration of food, be tried. The materials most commonly used for cultures are timothy hay, wheat and rice. These are boiled for a few minutes and then put in pond water at about the proportions of three inches of hay stem and three grains of wheat or rice to 100 cubic centimeters of water. After three or four days a bacterial scum may be seen on the surface and, if no Protozoa are present, some should be introduced. These proportions are about right for *Paramecium. Amoeba* requires a much lower concentration, *Euglena* a higher concentration. Rice appears to be somewhat better than wheat for the chlorophyll-bearing Protozoa. These cultures are usually at their best when from two to four weeks old. New cultures may be made at intervals, or old ones rejuvenated by adding small amounts of bread or dried lettuce. These suggestions are given for the interested amateur. For serious work, regular bacteriological techniques are followed, often to the point of raising cultures of particular kinds of bacteria for food. For detailed information the reader is referred to the papers and books on culture methods listed in the bibliography.

OUTLINE OF CLASSIFICATION OF PROTOZOA

Class MASTIGOPHORA (or *Flagellata*)

Usually with one or more flagella; with one kind of nucleus

Subclass PHYTOMASTIGINA

Usually with chromatophores; with one to four flagella

Order CHRYSOMONADINA

Minute yellowish or brownish, discoid forms with one or two flagella; many of them able to form pseudopodia; they sometimes lose flagella and form aggregations or colonies (palmella stage)

Common genera — *Synura*, *Uroglena*, *Dinobryon*

Order CRYPTOMONADINA

Body covered by pellicle and therefore of constant form; palmella stage not common; with one or two flagella; with one or two elongated brown, red or blue-green chromatophores

Common genus — *Chilomonas*

Order PHYTOMONADINA

With one or two flagella (seldom four or more); usually with many green chromatophores; usually with a cellulose body membrane

Common genera — *Chlamydomonas*, *Pandorina*, *Volvox*, *Eudorina*, *Gonium*, *Pleodorina*

Order EUGLENOIDINA

Body usually elongate; usually one, sometimes two or three flagella; chromatophores, when present, green; nucleus usually large and distinct

Common genera — *Euglena*, *Astasia*, *Phacus*, *Peranema*, *Trachelomonas*, *Heteronema*

Order DINOFLAGELLATA

Body with transverse and longitudinal grooves; usually with a transverse and a longitudinal flagellum; chromatophores brown

Common genera — *Peridinium*, *Ceratium*

Subclass ZOOMASTIGINA

A few free-living and many parasitic forms, some of great economic importance; no chromatophores; with one to many flagella; parabasal body and thread near nucleus

Order RHIZOMASTIGINA

With flagella and pseudopodia

Common genus — *Mastigamoeba*

Order PROTOMONADINA

No pseudopodia; with one or two flagella

Common genera — *Codosiga*, *Poteriodendron*, *Dendromonas*, *Stylobryon*, *Monas*, *Anthophysa*

(Common parasitic genera—*Trypanosoma*, *Leishmania*)

Order POLYMASTIGINA

Minute forms with three to eight or more flagella; mostly parasitic

(Common parasitic genus — *Giardia*)

Order HYPERMASTIGINA

With numerous flagella; parasitic in insects

Class SARCODINA (or *Rhizopoda*)

Forming pseudopodia; no pellicle, but often with internal or external skeletal structures

Subclass RHIZOPODA

Pseudopodia temporary, without axial rods

Order PROTEOMYXA

Pseudopodia thread-like, branching or joining one another

Common genus — *Vampyrella*

Order MYCETOZOA Slime Molds

Large multinucleate mass produced by fusion of several myxamoebae; occurring on decaying plant material; formerly considered to be closely related to the fungi

Order AMOEBINA

No pellicle or test

Common genera — *Amoeba*, *Pelomyxa*

Order TESTACEA

Body covered by a simple shell, usually with one opening through which the pseudopodia protrude

Common genera — *Arcella*, *Hyalosphenia*, *Difflugia*, *Centropyxis*, *Cucurbitella*, *Pontigulasia*, *Phryganella*, *Heleopera*, *Amphitrema*, *Pseudodifflugia*, *Euglypha*, *Cyphoderia*, *Trinema*, *Assulina*, *Nebela*, *Quadrulella*

Order FORAMINIFERA

Large marine forms, usually with perforated, calcareous tests

Subclass ACTINOPODA

Pseudopodia formed by fine, semi-permanent rods with cytoplasmic cover

Order HELIOZOA

Without internal capsule

Common genera — *Actinophrys*, *Actinosphaerium*, *Acanthocystis*, *Clathrulina*

Order RADIOLARIA

Body with a perforated internal capsule; marine

Class SPOROZOA

Parasitic; mature animal without locomotor apparatus

Class CILIATA (or *Infusoria*)

Possessing cilia or cirri (fused cilia); usually with macro- and micronucleus

Order HOLOTRICHA

Cilia uniformly distributed over entire body surface; no adoral zone of membranellae

Common genera — *Spathidium*, *Didinium*, *Coleps*, *Prorodon*, *Lacrymaria*, *Trachelophyllum*, *Amphileptus*, *Dileptus*, *Loxodes*, *Nassula*, *Chilodonella*, *Paramecium*, *Colpoda*, *Frontonia*, *Colpidium*, *Urocentrum*, *Cyclidium*

Order SPIROTRICHA

Adoral zone of membranellae winding clockwise; peristome not extending beyond body surface

Common genera — *Bursaria*, *Metopus*, *Spirostomum*, *Blepharisma*, *Stentor*, *Halteria*, *Oxytricha*, *Uroleptus*, *Urostyla*, *Kerona*, *Stylonychia*, *Euplotes*

Order CHONOTRICHA

Adoral zone winding clockwise; peristome extending beyond body in funnel-shape; usually attached to aquatic animals

Common genus — *Spirochona*

Order PERITRICHA

Adoral zone winding counter-clockwise; with an enlarged, disc-like, ciliated anterior region

Common genera —	*Epistylis*	*Vaginicola*
	Vorticella	*Cothurnia*
	Carchesium	*Trichodina*
	Zoothamnium	*Platycola*

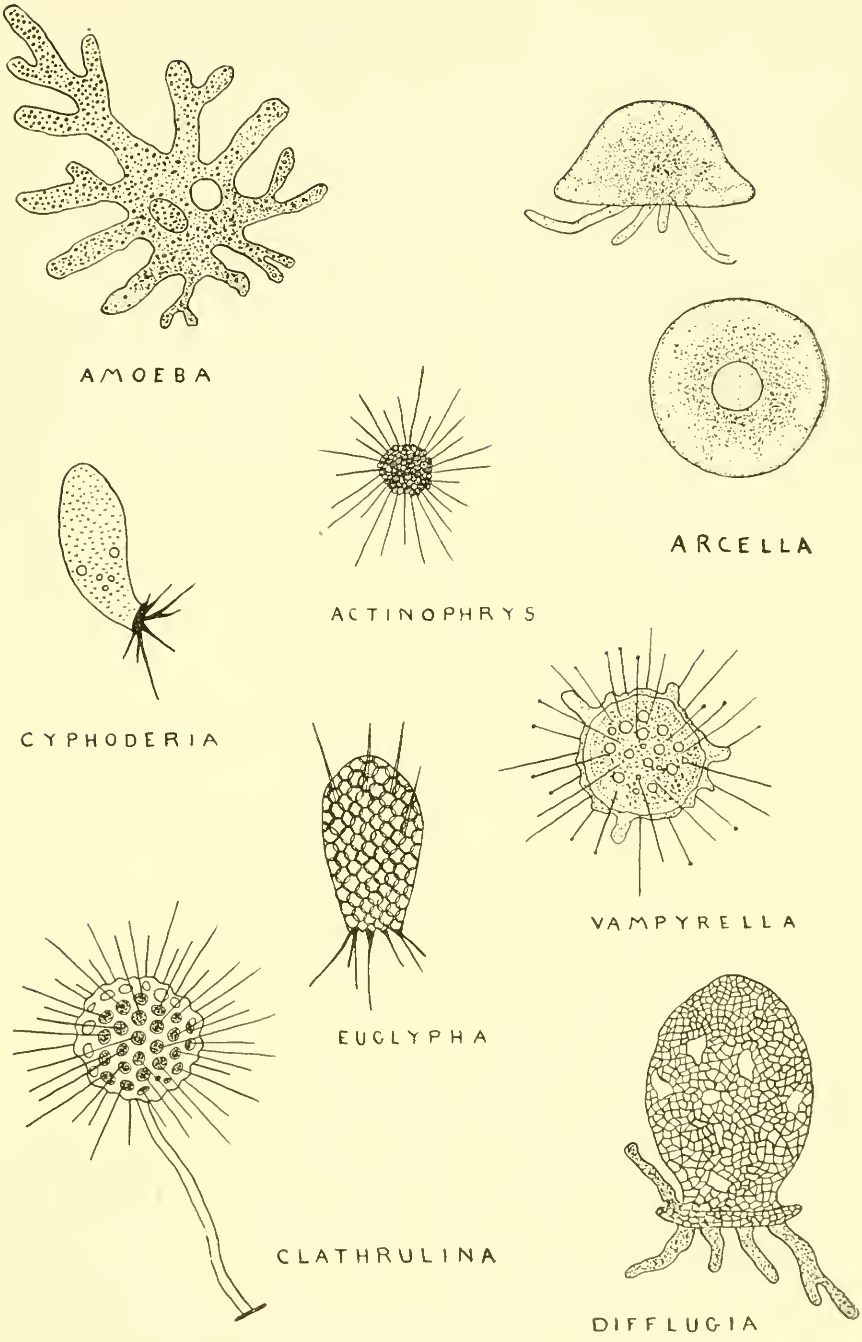
Class SUCTORIA

Mature animals with no locomotor structures; with suctorial and with piercing tentacles

Common genera —	*Dendrosoma*	*Sphaerophrya*
	Dendrocometes	*Acineta*
	Podophrya	*Solenophrya*

KEY TO THE COMMON GENERA OF PROTOZOA

1. Body with no fixed form or covered by a thin shell, moving with a slow, flowing motion rather than a rapid, swimming motion; hair-like structures, if present, in the form of stiff, ray-like projections—Rhizopods 2.
   Body with a fixed although often a very flexible form, usually swimming rapidly by means of a few long or many short, flexible or vibratile, hair-like structures, but sometimes attached or with tentacles 25.
2. Body not surrounded by a definite shell 3.
   Body almost or entirely surrounded by a shell 9.
3. Animal moving by means of broad or finger-like protoplasmic extensions or pseudopodia 4.
   Animal with hair-like rays 6.
4. Body orange or red; pseudopodia often anastomosing; with fine, pin-shaped rays, which are often unobserved
   Vampyrella Cienkowski
   Body almost colorless; no hair-like rays 5.
5. With a few very broad pseudopodia from one side of the body; containing many nuclei and symbiotic bacteria; found in sphagnum bogs
   Pelomyxa Greeff
   With many finger-like pseudopodia over body; seldom more than one nucleus; no symbiotic bacteria
   Amoeba Ehrenberg
   (*Chaos* Linn.)
6. Body orange or red; with pin-like rays and with broad pseudopodia
   Vampyrella Cienkowski
   Body almost colorless; with long spines or with long ray-like pseudopodia, or both 7.
7. With an external envelope with long spiny rays, some of which are forked at the end, in addition to hair-like pseudopodia
   Acanthocystis Carter
   No external envelope with spiny rays; with long, hair-like, unforked pseudopodia


AMOEBA
ARCELLA
ACTINOPHRYS
CYPHODERIA
VAMPYRELLA
EUGLYPHA
CLATHRULINA
DIFFLUGIA

8. With two body layers noticeable; rays larger towards the body, tapering outwards
Actinosphaerium Stein
Body appearing to be a mass of bubbles; rays entirely hair-like
Actinophrys Ehrenberg
9. Pseudopodia hair-like, often branching 10.
Pseudopodia broad or finger-like 15.
10. Shell with the opening at one side of the end 11.
Shell symmetrical 12.
11. With a narow neck curved to one side, bearing the mouth; shell chitinous, with small plates
Cyphoderia Schlumberger
End of shell bearing the mouth oblique; shell with siliceous plates
Trinema Dujardin
12. Shell spherical, with many small, window-like apertures from which the rays protrude; usually on the end of a stem
Clathrulina Cienkowski
Shell inverted cup- or vase-shaped, with one opening from which the rays protrude; no stem 13.
13. Shell with attached sand grains and similar material
Pseudodifflugia Schlumberger
Shell with definite plates 14.
14. Opening of shell with prominent saw-tooth edges; shell usually with spines
Euglypha Dujardin
Opening of shell with minute serrations; no spines
Assulina Ehrenberg
15. Shell discoidal or hemispherical, often resembling a doughnut when seen from above; color often brown 16.
Shell usually bottle- or flask-shaped; colored or not 18.
16. Shell smooth, without sand grains or foreign material
Arcella Ehrenberg
Shell coated with sand or foreign material 17.
17. Shell hemispherical, with a large opening in the middle of the flat side
Phryganella Penard
Shell discoidal, compressed laterally, with the opening on one side, eccentric
Centropyxis Stein
18. Shell transparent, without sand grains and not divided into plates
Hyalosphenia Stein
Shell with plates or with attached sand grains or similar material 19.
19. Shell coated with sand grains or similar material 20.
Shell composed of chitinous plates 23.
20. Shell not constricted by an internal granular collar; shell usually pear-shaped 21.
Opening of shell constricted by an internal granular collar; shell usually elliptical 22.
21. With opening at one end only
Difflugia Leclerc
With openings at both ends
Amphitrema Archer

22. Shell with a short neck
Cucurbitella Penard
Shell with a long neck
Pontigulasia Rhumbler

23. Plates squarish
Quadrulella Cockerell
(*Quadrula* Schulze)
Plates rounded or irregular 24.

24. Shell pear-shaped; animal not brightly colored
Nebela Leidy
Shell spherical or ovoid; animal green, yellow or red
Heleopera Leidy

25. With several thickened tentacles used for food-gathering but not for locomotion—Suctoria 26.
With a few long or many short, flexible or vibratile, hair-like processes (shown by the movement of the surrounding water, even when they are not visible) 31.

26. Tentacles much branched, flexible but not contractile
Dendrocometes Stein
Tentacles contractile, not branched 27.

27. Body with a semi-transparent sheath or lorica, which is usually sac-like, cubical or triangular 28.
No lorica; animal colonial, plant-like, or else almost spherical, with or without a stalk 29.

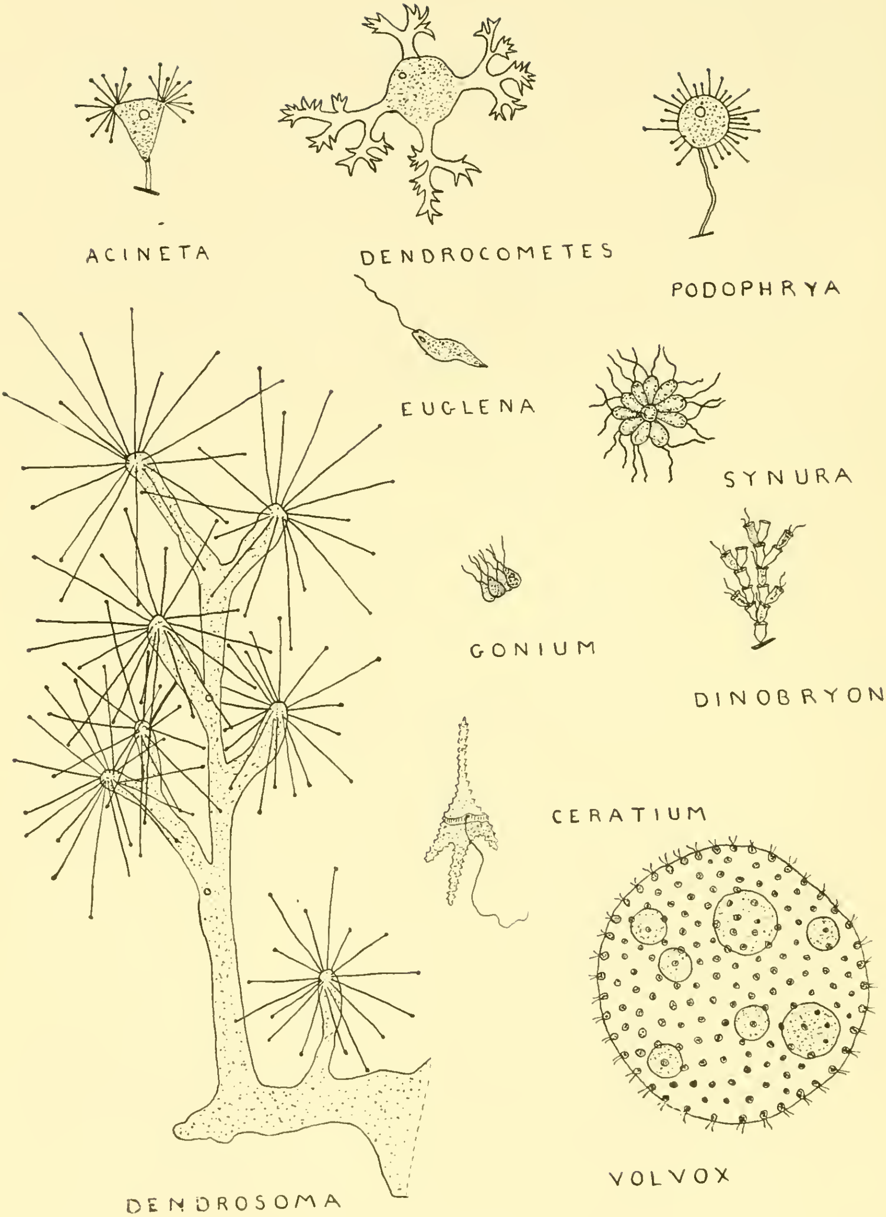
28. Lorica cubical, sac-like
Solenophrya Claparède & Lachmann
Lorica an inverted triangle, with a short stalk; tentacles extending from the two upper corners
Acineta Ehrenberg

29. A colonial, plant-like form, with tentacles at the ends of the branches
Dendrosoma Ehrenberg
Animal almost spherical, with or without a stalk 30.

30. At the end of a thin stalk
Podophrya Ehrenberg
No stalk
Sphaerophrya Claparède & Lachmann

31. With a few (usually one to ten) long, vibratile, hair-like structures (flagella), often difficult to see but indicated by the water currents; in colonial forms, each individual of the colony may have one or more flagella—Flagellates 32.
With many, short, vibratile, hair-like structures (cilia) over or around the body—Ciliates 55.

32. Body colored wholly or in part; chromatophores (color bodies) usually present (usually brown, yellow or green) 33.
Body not colored or only slightly brownish 46.


ACINETA
DENDROCOMETES
PODOPHRYA
EUGLENA
SYNURA
GONIUM
DINOBRYON
CERATIUM
VOLVOX
DENDROSOMA

33. In colonies 34.
Single individuals 41.

34. Colonies plant-like, branching; each animal of colony enclosed in a transparent sheath or lorica
Dinobryon Ehrenberg
Colonies plate-like or spherical 35.

35. Colony plate-like; flagella on one side only
Gonium Müller
Colony almost or quite spherical; flagella not limited to one side 36.

36. Cells of the colony reaching to the center 37.
Cells of the colony distributed around the surface of a sphere 38.

37. With many cells loosely joined, with no common envelope
Synura Ehrenberg
(*Uvèlla*)
With sixteen to thirty-two cells enclosed within a common envelope
Pandorina Bory

38. Individuals very numerous, pear-shaped, each usually with two yellow chromatophores
Uroglena Ehrenberg
Individuals spherical, each with many green chromatophores 39.

39. With all cells of the colony of uniform size
Eudorina Ehrenberg
With many small vegetative and large reproductive cells present 40.

40. With the small, vegetative cells at one end of the colony and the large, reproductive cells at the other
Pleodorina Shaw
With the large and small cells mixed
Volvox Linn.

41. With a membrane of distinct plates covering the animal 42.
No plates 43.

42. Body ovate
Peridinium Ehrenberg
With long, horn-like processes on the plates
Ceratium Schrank

43. Body with one large green chromatophore
Chlamydomonas Ehrenberg
Body almost uniformly colored brown or green 44.

44. Body encased in a thick sheath and only slightly flexible; color brown
Trachelomonas Ehrenberg
Body flexible, not encased in a thick sheath; color green 45.

45. Body globular to cylindrical, widest in the middle, not flattened
Euglena Ehrenberg
Body flattened, widest at the front end
Phacus Nitzsch

46. Forming colonies, usually plant-like, branching 47.
Living singly 50.

47. Animals in a dense cluster, usually at the end of a stem 48.
With one animal at the end of each branch 49.

48. Each animal with a sheath, the collar-like part of which extends beyond the animal a distance equal to the body length; stem slender
Codosiga Kent
Animals without collars; colony with or without a stout stem
Anthophysa Bory

49. Stem branching repeatedly, each time into two, with animals at the tips of the branches
Dendromonas Stein
Stems springing from the cup-like sheath of the animal next below
Poteriodendron Stein
(*Stylobryon* de Fromentel)

50. Body shape changing very little; with two or three flagella 51.
Body very flexible, varying in shape from oval to elongate; one or two flagella 52.

51. Body spherical to ovate; with one long flagellum and one or two short ones
Monas Ehrenberg
Body elongate, with the anterior end truncated or indented; with two nearly equal flagella
Chilomonas Ehrenberg

52. Shape very changeable, often putting out pseudopodia, like an amoeba
Mastigamoeba Schulze
Body very flexible, but not putting out pseudopodia 53.

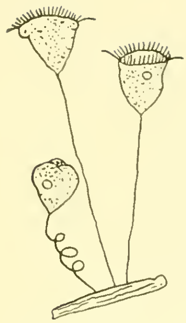
53. With two unequal flagella, one directed forwards and one trailing; body usually widest in the middle
Heteronema Dujardin
With one long or with one long and one very short flagellum, directed forwards; body very changeable, but in motion usually getting wider towards the rear 54.

54. Posterior end flattened or truncated when animal is in motion
Peranema Dujardin
Posterior end more or less rounded or tapering
Astasia Dujardin

55. Colonial or permanently attached animals 56.
Single, free-swimming individuals 63.

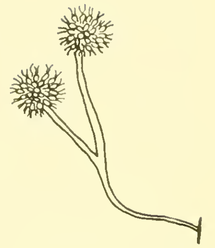
56. Animal almost surrounded by a transparent or granular sheath; with or without a short stem 57.
No such sheath; with a long stem 60.

57. Animal trumpet-shaped; with long cilia around the mouth region and short cilia over the body
Stentor Oken
Animal vase-shaped; with cilia around the mouth region but not on the body 58.

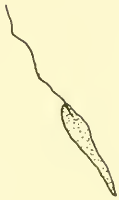


VORTICELLA

CHILOMONAS

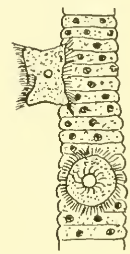


ANTHOPHYSA



ASTASIA

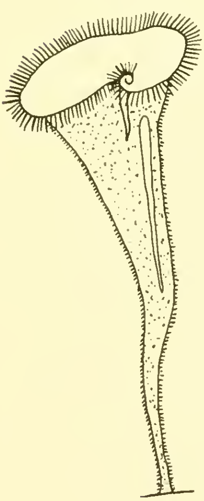
HETERONEMA



TRICHODINA ON HYDRA

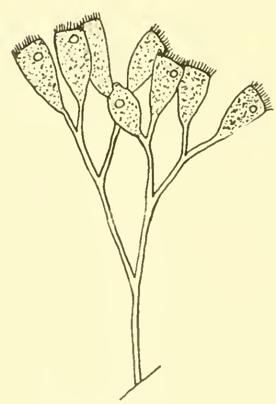
MASTIGAMOEBA

CODOSIGA



STENTOR

COTHURNIA



EPISTYLIS

58. Sheath with a short stem
Cothurnia Ehrenberg
No definite stem 59.
59. Upright, attached at base
Vaginicola Lamarck
Recumbent, attached along side
Platycola Kent
60. Stem spirally coiled, unbranched
Vorticella Linn.
Stem branched, with several animals in groups at the ends 61.
61. Animals, but not the main stem, contractile
Epistylis Ehrenberg
Both stem and animals contractile 62.
62. Branches of the stem contracting independently of each other
Carchesium Ehrenberg
Branches all contracting together
Zoothamnium Bory
63. With one or two rings of long cilia 64.
Cilia not arranged in rings, except sometimes to encircle the mouth region 67.
64. Animal drum- or barrel-shaped, with a posterior ring of cilia; usually living on *Hydra*, amphibians, etc.
Trichodina Ehrenberg
Animal cocoon- or thimble-shaped, with one or two rings of cilia around the body; usually free-swimming 65.
65. With a tail-like process
Urocentrum Nitzsch
No tail-like process 66.
66. Body spherical, with a belt of very long cilia around the middle; moving by jerks
Halteria Dujardin
Body thimble-shaped, with the flat end bearing a knob-like projection on which is the mouth; with two belts of cilia
Didinium Stein
67. With a shell of small, regularly arranged plates
Coleps Nitzsch
No shell 68.
68. With one to five long bristles or spines on rear of animal 69.
Not so 71.
69. With cilia all over the body; usually with one to several posterior bristles
Cyclidium Müller
No cilia on the dorsal surface; usually with three to five terminal bristles 70.
70. Body elongated; usually with three posterior bristles
Stylonychia Ehrenberg
Body oval; about five posterior bristles
Euplotes Ehrenberg
71. Body trumpet- or bag-shaped, with a row of cilia around the funnel-shaped mouth area 72.
Not so 73.

72. Body trumpet-shaped
Stentor Oken
Body bag-or purse-shaped
Bursaria Müller

73. With a narrow, neck-like or tail-like extension at one end of the body 74.
Not so 78.

74. Posterior narrowed into a tail-like region
Uroleptus Ehrenberg
Anterior narrowed into a neck-like region 75.

75. Neck short 76.
Neck long 77.

76. Neck extensile
Trachelophyllum Claparède and Lachmann
Neck not extensile
Amphileptus Ehrenberg

77. Body flat, ribbon-like
Dileptus Dujardin
Body long-ovate, not flattened
Lacrymaria Ehrenberg

78. Body, when extended, long and slender, worm-like
Spirostomum Ehrenberg
Body not worm-like, not usually capable of great extension 79.

79. With cilia on the ventral side; no cilia on the dorsal surface, but sometimes with a few bristles dorsally; usually swimming or moving with one surface uppermost 80.
With cilia all over the body; usually swimming with a revolving or spiral motion 83.

80. With oblique rows of ventral cilia; on *Hydra*
Kerona Ehrenberg
Ventral cilia scattered or in lengthwise rows; usually free-swimming 81.

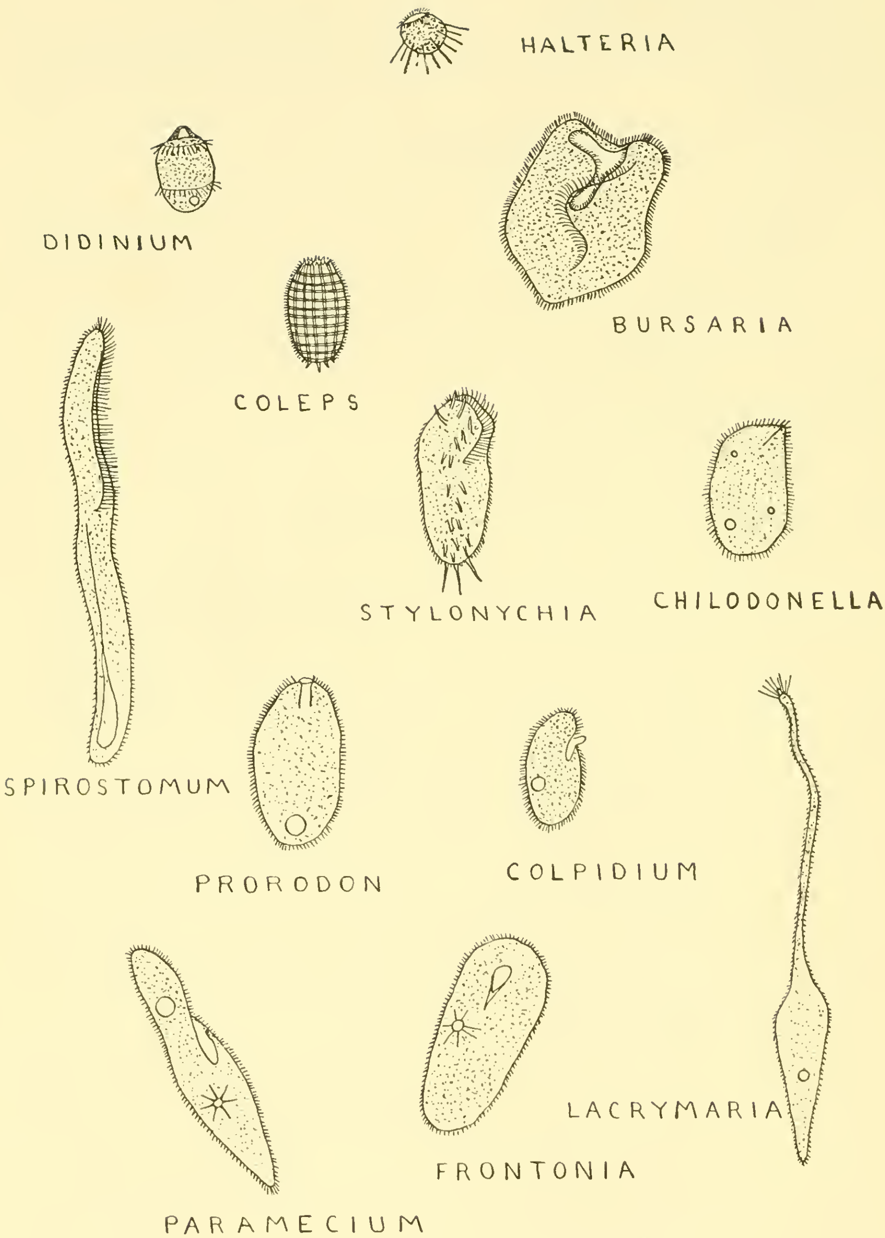
81. Anterior end asymmetrical
Chilodonella Strand
(*Chilodon* Ehrenberg)
Anterior end almost evenly rounded 82.

82. With many cilia in lengthwise rows on the ventral surface
Urostyla Ehrenberg
With scattered ventral cilia
Oxytricha Ehrenberg

83. Mouth almost or quite at the front end of the body 84.
Mouth set about one-fourth or more of the way back 85.

84. Front end oblique, bearing the mouth
Spathidium Dujardin
Animal evenly rounded on both ends
Prorodon Ehrenberg

85. With a long groove leading to the mouth 86.
Not so 89.


HALTERIA
DIDINIUM
BURSARIA
COLEPS
SPIROSTOMUM
STYLONYCHIA
CHILODONELLA
PRORODON
COLPIDIUM
LACRYMARIA
FRONTONIA
PARAMECIUM

86. Cilia fused into an undulating membrane along the groove leading to the mouth 87.
No such membrane 88.
87. Anterior end pointed, somewhat hooked; color commonly pink
Blepharisma Perty
Anterior end rounded; practically colorless
Metopus Claparède and Lachmann
88. Anterior end asymmetrical, somewhat hooked; ventral surface concave
Loxodes Ehrenberg
Anterior end rounded; animal cigar-shaped
Paramecium Hill
89. Anterior end of body narrower than the posterior and usually somewhat asymmetrical 90.
Animal almost evenly oval or with the anterior end slightly wider than the posterior 91.
90. Body flattened sideways; no undulating membrane around the mouth
Colpoda Müller
Body scarcely flattened sideways; with an undulating membrane around the mouth
Colpidium Stein
91. Body lengthened, usually uncolored
Frontonia Ehrenberg
Body ovate, usually red or brown
Nassula Ehrenberg

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MOSS-LIKE AND JELLY-LIKE ANIMALS

Chapter 3

Under the heading of moss-like and jelly-like animals are grouped some forms which our modern system of classification separates into three distinct phyla and which, in spite of their superficial likenesses, are really distant relatives. Until modern microscopes revealed the details of their structures, all of these creatures were placed, even by the scientist, as zoophytes or plant-animals.

The first of these groups is the *Porifera* or Sponges, most of which are marine, but which have several small fresh-water forms. None of these much resembles the skeleton of the marine sponge, which we use for washing purposes, but may be truly called moss-like. They form mats or irregular masses on the under sides of floating logs and boards and sometimes are found as patches around the submerged stems of rushes. The resemblance to mosses is still further increased in some of the common species by the green color, which is probably due to associated or symbiotic algae. Sponges are usually distinctive, however, in having a characteristic odor, which has been described by some writers as resembling that of garlic. Occasionally under favorable conditions sponges become very numerous and have been known to grow in and even fill the pipes from reservoirs.

The shape of the sponge colony varies and the only reasonably constant character upon which identification can be based is the form of the silicious needles or spicules which are embedded in and support the body wall. There are usually two kinds of spicules in the body wall: large skeletal spicules, which are often bound together in bunches, and smaller flesh spicules, which are scattered through the body mass. Spicules of a somewhat different character are developed around the gemmules or small masses of cells by means of which the sponge reproduces itself. These gemmules arise throughout the body and appear as small, round, dark objects in the sponge colony. They become most numerous in the autumn and live through the winter, after the colony has disintegrated. Autumn is the best time to collect sponges, since gemmules are usually necessary for positive identification. Sponges may be merely dried out, when gathered. Later the collector can crush a portion in a drop of water for examination and identification under the microscope at his leisure. Hot nitric acid is often used to dissolve the sponge mass, after which the spicules are washed off and examined more easily.

The next group in this series is called the *Coelenterata*, the fresh-water forms of which are mainly plant-like. Back in 1744 a man named Trembley kept an aquarium to interest the boys he was tutoring, and he himself became deeply engrossed in some tiny, thread-like, tentacled creatures which appeared there. It is said that, in order to determine whether they were plants or animals, he attempted to grow more of them from cuttings, just as we do geraniums and other house plants. The creatures did grow from cuttings, but Trembley observed enough of their activities while watching them to leave little doubt that they were animals. He later published a book describing the hydras and their marvelous powers of reduplicating or regenerating lost parts.

Hydras may usually be found attached to water plants, such as *Elodea,* in cool and quiet water. When the plants are lifted from the water, the animals contract into tiny points of jelly, but, if they are put into a glass container with pond water, they will be seen to expand again in a short time. Hydras may often be collected in great quantities by bringing in a bucket full of water plants and putting them into a container with just enough pond water to cover them. As the mass becomes foul, which it usually does within two or three days, the hydras float up to the surface in search of more oxygen and may be easily taken out with a pipette. To remove them from a plant requires quick action because, if given any warning, they grip their perch so securely that the suction of a pipette has little effect upon them.

A hydra in a drop or two of water with other small organisms well repays observation. It reaches out for its prey with its tentacles, which shoot out tiny poisoned arrows or nematocysts. The stupefied victim is grabbed by these tentacles, pushed into the mouth which lies among them, and forced on into the body, often distending it most grotesquely. Hydras are sometimes reported to be a source of loss in fish hatcheries. Although the young fish are usually too big to be swallowed by the hydras, they are often poisoned by the nematocysts.

Hydras ordinarily reproduce by budding, a protrusion from the side gradually developing into a complete animal that eventually becomes detached from its parent. In autumn or when living conditions become unfavorable, sex organs, spermary and ovary, may appear. The fertilized egg develops into a group of cells called a planula, which rests over until conditions become favorable for its development into a complete hydra. Many marine Coelenterates have a peculiar method of reproduction by which the offspring resembles the grandparent rather than the parent. A hydra-like animal gives rise to a medusa, a bell-shaped "jelly-fish", which in its turn gives rise to more hydra-like forms. Such metagenesis or alternation of generations is rare in fresh-water Coelenterates, but occurs occasionally. *Craspedacusta,* such a medusoid form, has been found several times in different places in America and Europe.

The third group of animals under consideration may be either moss-like or jelly-like. They are called *Bryozoa,* meaning "moss animals", and are among the most fascinating of minute creatures, when seen under favorable conditions. They are usually found in quiet streams, lakes and ponds. Some build little tubes on sticks and stones and, since they branch freely, the colony soon takes on the appearance of a plant or a clinging vine. Others secrete masses of jelly in the surface of which they remain embedded. One spectacular form, *Pectinatella,* frequently builds up a spherical or oval colony a foot or more in diameter, which cannot fail to excite the wonder and admiration of the July or August observer. The full beauty of these colonies is seldom appreciated, however, for the individual animals are very timid and retreat into their protective sheaths until fully assured that all is well. The colony should be taken up carefully and put into a suitable glass container, so that it may be covered with water and still be available for observation. One will find it well worth the time and patience required to watch the surface of the colony with a hand lens. Gradually each little animal in the group extends a pinkish head and a lophophore or crown of waving tentacles, until the whole mass appears to be a garden of delicate flowers. These fragile tentacles are for the prosaic task of pulling in the microscopic organisms upon which the animals feed and also serve the naturalist as an aid in identifying the various species.

Like Sponges, the *Bryozoa* form little, well-protected globules of cells, which carry over the winter. Instead of gemmules, these are called statoblasts. Some forms bear a series of hooks which serve to anchor them until they are ready to begin growth. In September, when the colonies usually disintegrate, these statoblasts, looking superficially much like fig seeds, are often found in rows or masses along the shores of our lakes and ponds. As in the sponges, the reproductive bodies are often necessary for positive identification.

OUTLINE OF CLASSIFICATION OF FRESH-WATER MOSS-LIKE AND JELLY-LIKE ANIMALS

Phylum PORIFERA

Sessile, aquatic animals with calcareous, siliceous or spongin fibers supporting the body; numerous pores in the body wall open into a central gastral chamber

Class NONCALCAREA

Spicules siliceous or spongin

Order TETRAXONIDA

Body spicules four-rayed or single, never three or six-rayed

Family HAPLOSCLERIDAE

Long (body) spicules with both ends alike; small spicules not greatly recurved on ends

Subfamily SPONGILLINAE

Fresh-water sponges, with body spicules straight or slightly curved, gemmule spicules plain or birotulate; reproduction asexual, by gemmules

Seven genera — *Spongilla*, *Ephydatia*, *Heteromeyenia*, *Asteromeyenia*, *Dosilia*, *Trochospongilla*, *Carterius*

Phylum COELENTERATA

Radially symmetrical animals with a gastrovascular cavity and no coelom; middle body layer primarily noncellular; body, and especially the tentacles, with nettle cells or nematocysts

Class HYDROZOA

Hydroid stage usually evident; medusa usually minute or reduced to sporosac

Order HYDRARIAE

Elongate, cylindrical animals, attached or free-floating; mostly in fresh water; no medusae

Three genera — *Chlorohydra*, *Hydra*, *Pelmatohydra*

Order TUBULARIAE

Colonial forms; hydranth without hydrotheca; no medusa in fresh-water genus

One genus — *Cordylophora*

Order TRACHOMEDUSAE

Hydroid stage omitted or minute; medusa with a velum

One genus — *Craspedacusta*

Phylum BRYOZOA

Colonial, aquatic animals; with tentacles on a ridge around the mouth; digestive tract U-shaped; with coelom

Class ENTOPROCTA

Anus within circle of lophophore; lophophore circular, with a single row of tentacles which cannot be completely retracted

Family URNATELLIDAE

Each colony consisting of a few zooids which rise from a common disc; stalks long, jointed, branching

One genus — *Urnatella*

Class ECTOPROCTA

Anus outside lophophore, which can be completely retracted

Order GYMNOLAEMATA

Lophophore circular

Family PALUDICELLIDAE

With chitinous tubes and partitions between club-shaped zooids

Two genera — *Paludicella*
Pottsiella

Order PHYLACTOLAEMATA

Lophophore lyre-shaped or almost circular

Family FREDERICELLIDAE

Colony branched, with chitinous, non-jointed tubes; lophophore almost circular

One genus — *Fredericella*

Family PLUMATELLIDAE

Colony branched, with chitinous, jointed tubes or lobed sacs; lophophore lyre-shaped; statoblasts without spines

Two genera — *Plumatella*
Lophopus

Family LOPHOPODIDAE

Colony small, compact; lophophore lyre-shaped; statoblasts oval, with spines on each end

One genus — *Lophodella*

Family CRISTATELLIDAE

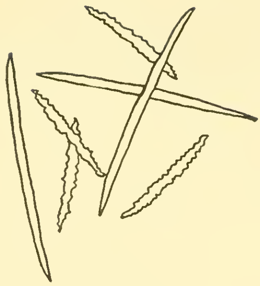
Colony with gelatinous matrix; lophopore lyre-shaped; statoblasts each with one or two completely encircling rows of marginal spines

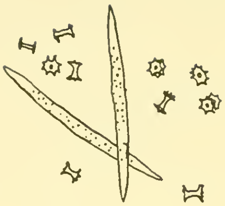
Two genera — *Pectinatella*
Cristatella

KEY TO THE PRINCIPAL GENERA OF MOSS-LIKE AND JELLY-LIKE ANIMALS

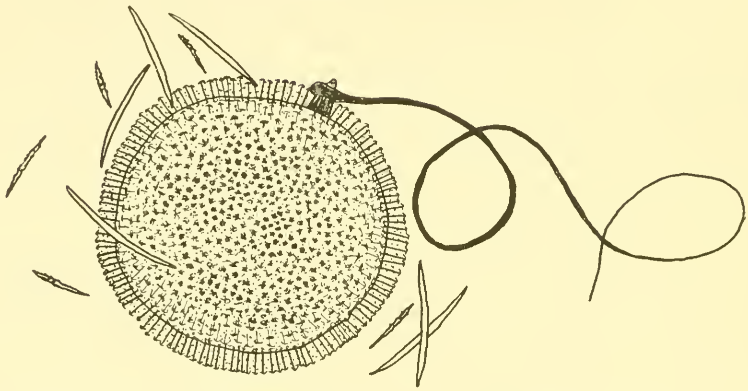
1. Individual animals usually with, but rarely without, tentacles; without spicules 2.
   Without tentacles; usually with spicules in the colony mass *Porifera* or Sponges 3.

2. Animals solitary, with the frequent exception of one or two sprouts or buds, or else colonial, plant-like, with tentacles arising from over the bodies of the individual animals; tentacles not retractile into a protective sheath, although often capable of great contraction; with one opening to the digestive tract—Coelenterates 9.
   Animals colonial, resembling a small plant, a patch of moss or a mass of jelly; tentacles in a circular or double horseshoe arrangement around the mouth of each animal, partially or wholly retractile within a pro-

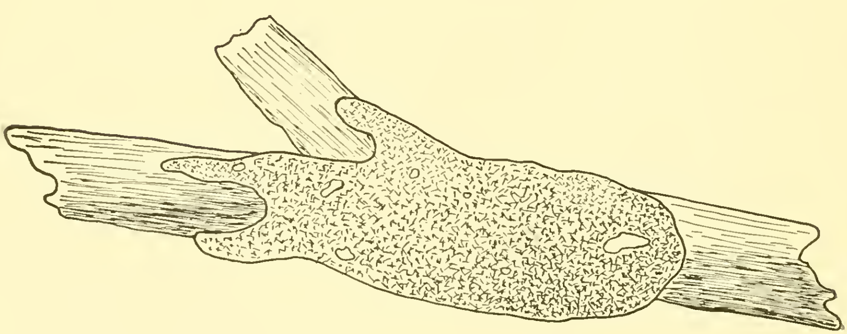




SPONGILLA SPICULES EPHYDATIA SPICULES
(BOTH MUCH ENLARGED)



CARTERIUS GEMMULE (MAGNIFIED)



SPONGE COLONY ON A STICK

tective sheath; digestive tract of individual animals U-shaped, with the mouth and anus near together—*Bryozoa* or Moss Animals 14.

3. Spicules spine- or quill-like
   Spongilla Lamarck
   Some of the gemmule spicules birotulate (formed of a rod with a disc or cap on each end, resembling a spool or bobbin) 4.

4. Opening to gemmule (reproductive bud) spout-like, with one or more filaments or tendrils from the end
   Carterius Potts
   No tendrils or filaments from the openings to the gemmules 5.

5. Gemmules with two kinds of birotulate spicules 6.
   Gemmules with one kind of birotulate spicules, which may vary somewhat in size 7.

6. Flesh spicules quill-like or absent
   Heteromeyenia Potts
   Flesh spicules star-shaped
   Asteromeyenia Annandale

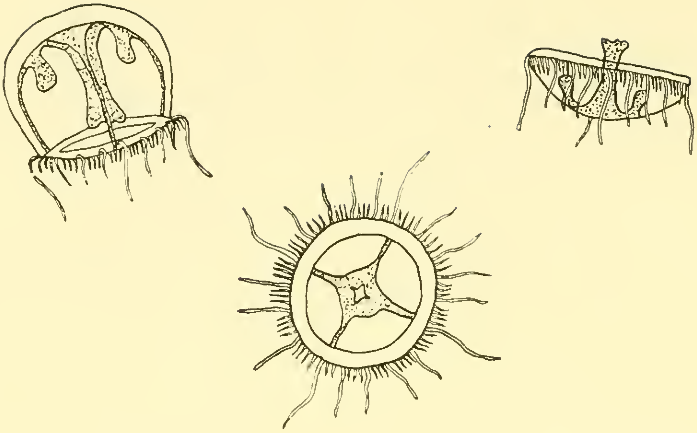
7. With the disc-shaped ends of the birotulate spicules with smooth margins
   Trochospongilla Vejdovsky
   Ends of birotulate spicules with serrated margins 8.

8. Flesh spicules star-shaped
   Dosilia Gray
   Flesh spicules not so, often absent
   Ephydatia Lamouroux

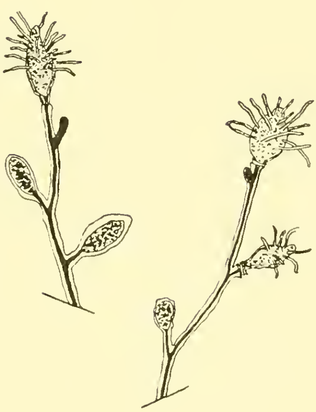
9. Branching, plant-like, colonial animals; tentacles scattered over the bodies of the individual animals; colonies stationary, attached to sticks, vegetation, etc.
   Cordylophora lacustris Allman
   Single animals, often with one or more sprouts or buds; tentacles, if present, in a ring around the mouth area 10.

10. With two generations differing greatly in appearance; the common, sexual generation is bowl-shaped, with a ring of tentacles around the mouth area, and is free-swimming; the less familiar, asexual generation is very small, cylindrical (often with sprouts or buds), without tentacles, and attached to plants, sticks, etc.
    Craspedacusta ryderi (Potts) Medusa or Jelly-fish
    (*Craspedacusta sowerbyi* Lankester)
    No alternation of generations; body cylindrical (excepting buds or sexual organs in the body wall), with a ring of tentacles around the mouth; usually attached to water plants, but capable of free motion—Hydras 11.

11. Animal bright green in color
    Chlorohydra viridissima (Pallas) Green Hydra
    (*Hydra viridis* Linn.)
    Body whitish, brownish or reddish 12.

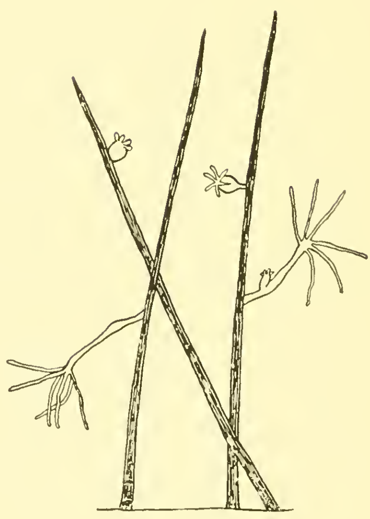


CRASPEDACUSTA



CORDYLOPHORA

(MAGNIFIED)



HYDRA (ON WATER GRASS)

12. Basal portion of body much narrowed to form a slender stalk
Pelmatohydra oligactis (Pallas) Brown Hydra
(*Hydra fusca* Linn.)
Body more uniform—*Hydra* Linn. (several species) 13.

13. Tentacles, when extended, much longer than the extended body
Hydra carnea Agassiz Red Hydra
Tentacles shorter than the body; color whitish
Hydra americana Hyman Common or Gray Hydra
(*Hydra vulgaris* Pallas)
(*Hydra grisea* Linn.)

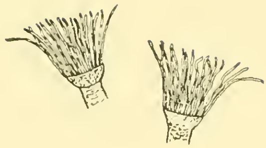
14. Colony in a more or less spherical, flattened, triangular or ribbon-like mass; statoblasts (groups of cells set apart for vegetative reproduction) with marginal, hooked spines; lophophore (crown of tentacles of each animal of the colony) appearing divided, lyre-shaped or somewhat resembling a pair of wings 15.
Colony somewhat lobed, branching or plant-like, sometimes forming a conspicuous mass but often very small; statoblasts without hooked spines or projections; lophophore lyre-shaped or circular 17.

15. Colonies usually very small, somewhat triangular; usually on water plants; statoblasts oval, with several graduated, hooked spines or projections on each end, which spines usually bear two to eight hooks or prongs distributed along the sides of the spines out to the ends; colony capable of very slow motion; recently discovered near Philadelphia and in Lake Erie and probably recently introduced into this country
Lophodella carteri (Hyatt)
(*Lophopodella carteri* (Hyatt))
Colonies usually large enough to be quite noticeable, sac-like or ribbon-like; statoblasts more rounded, with one or two completely encircling rows of marginal spines, which bear two or more hooks or prongs at their ends 16.

16. Colony flattened on the under side, long and narrow; with the power of extremely slow motion; becoming one-quarter of an inch by eight inches; on twigs, the under sides of lily pads, etc.; statoblasts with a double row of more than twenty-five marginal spines, some of which have more than two hooks or prongs at the ends
Cristatella mucedo Cuvier
Colony sac-like; incapable of moving; becoming extremely large; attached to sticks, etc.; statoblasts with a single row of less than twenty-five marginal spines, which have two prongs or hooks at the ends
Pectinatella magnifica Leidy

17. Lophophore with more than thirty tentacles and appearing divided, lyre-shaped or somewhat resembling a pair of wings 18.
Lophophore with less than thirty tentacles in a circular arrangement 20.

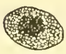
18. Colony somewhat glove-shaped, very small; on roots of duck-weed, on plant stems, etc.; mature statoblasts pointed or drawn out at each end, with a brownish, cellular marginal ring
Lophopus cristallinus (Pallas)
Colony plant-like, sometimes small or sometimes forming a conspicuous



FREDERICELLA

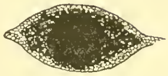
LOPHOPUS

LOPHOPHORES (MAGNIFIED)

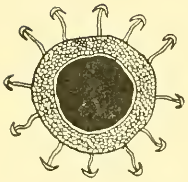


PLUMATELLA

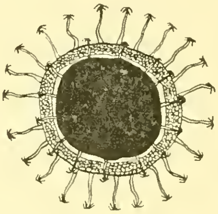
FREDERICELLA



LOPHOPUS

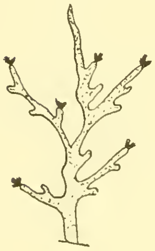


PECTINATELLA

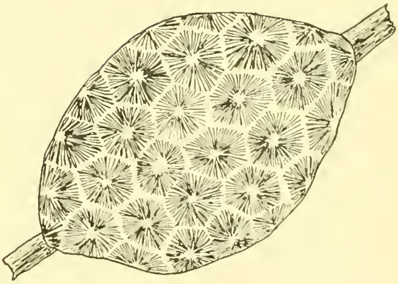


CRISTATELLA

STATOBLASTS (MAGNIFIED)



PLUMATELLA



PECTINATELLA

(REDUCED)

COLONIES

mass, on under sides of sticks and stones, in water pipes, etc.; statoblasts oval, with a brownish, cellular marginal ring 19.

19. Apertures in cones that appear as swellings on the main branches
Hyalinella punctata (Hancock)
Apertures at the ends of stems from the main branches
Plumatella repens Kraepelin

20. Stem not jointed; statoblasts oval, without a cellular marginal ring
Fredericella sultana (Blumenbach)
Stem jointed, or with partitions between the individual animals; statoblasts, in the familiar forms, oval, with a purplish, cellular marginal ring 21.

21. Tentacles not completely retractile; no statoblasts known; rare
Urnatella gracilis Leidy
Tentacles completely retractile **22.**

22. Individual animals long-cylindrical, arising erect from a stem; no statoblasts known; rare
Pottsiella erecta (Potts)
Individual animals attached directly to each other in a more or less branching arrangement; statoblasts oval, with a purplish, cellular marginal ring; on the under sides of stones, etc.; common
Paludicella articulata (Ehrenberg)

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ROTIFERS AND GASTROTRICHA

Chapter 4

In the year 1703 the Dutch scientist, Leeuwenhoek, saw through his home-made microscopes many peculiar little animals which appeared to have tiny wheels rotating at their anterior ends. Later workers confirmed his report, and these little animals, multicellular but often no larger than many of the Protozoa, were called *Rotifera,* or "wheel-bearing" animals. It is now known that this wheel effect is an optical illusion caused by the successive motions of cilia which form a single or double ring around the mouth. The chief purpose of this corona or ring of cilia is to create a little whirlpool which will drag unfortunate passers-by into the ever ready mouth of the rotifer. Once engulfed there is no escape, for in the throat of the animal and plainly visible through its transparent body is a mastax or set of jaws which soon disposes of any morsel which may reach it. Some of the rotifers have reduced the corona and developed the ability to project a forceps-like mastax out at the mouth and so grab their prey. Others have become vegetarians and have adapted the mastax into a sucking pump, highly efficient in extracting the contents of plant cells.

Some of the *Rotifera* are sac-like forms, but many have a characteristic posterior extension of the body called the foot, which may fork at the end into two or three toes. This foot serves as a rudder in swimming and as an anchor when the animal rests. Frequently the foot shows several joints and is capable of folding up or of extending like a telescope.

Most rotifers are solitary nomads, but a few species have developed colonial habits and, like *Conochilus,* may be found in spherical, floating colonies, all hooked together by their feet. Some appear to feel the need for protection and secrete thin and usually transparent tubes around themselves. In time of danger the head can be withdrawn into this protective sheath, which is called the *lorica.* Other rotifers have settled down and built themselves homes. One of the most beautiful of these, *Floscularia,* puts out a finger-like projection from the region back of the head and makes up tiny bricks with which it builds itself a delicate, chimney-like house.

Rotifera, like Protozoa, are found in almost all standing water, even in temporary puddles and the cavities of pitcher-plant leaves. They are commonly associated with small aquatic plants, especially with algae, or with decaying vegetation. Several species are often found on *Spirogyra,* the alga popularly called "pond scum", upon which they feed by sucking out the cell contents. One rotifer, *Ascomorpha,* spends most of its life inside the spherical protozoan colony, *Volvox.*

In the *Rotifera* the sexes are separate and the emancipation of the female is quite complete. She may live her whole life and produce innumerable off-spring without ever meeting a male. As a matter of fact, males are very rare, small, and lack mouth and stomach. They usually occur in the autumn and mate with the females who then produce a special type of egg which survives the winter and produces females for the next spring. During spring and summer these females produce eggs which hatch without fertilization into more females. In the autumn, smaller, male-producing eggs are also laid. This process of development without fertilization is called parthenogenesis and is fairly common among invertebrate animals.

Another odd group of animals, often classed with the rotifers and likely to puzzle the amateur microscopist, is the *Gastrotricha*. The name comes from two Greek words meaning "hairy stomach" and refers to the ciliated ventral surface. These animals are widely distributed and are usually present wherever Protozoa and rotifers are found. Occasionally they get to be twice as long as a *Paramecium* but are usually about the size of, and are commonly mistaken for, large ciliate Protozoa. They are usually covered with small scales or with spines. They generally have two posterior toes, as do many rotifers, but lack the telescoping foot. Little is yet known of the American forms and their habits.

OUTLINE OF CLASSIFICATION OF GASTROTRICHA

Order CHAETONOTOIDEA

Marine or fresh-water animals with one pair of cement tubes posteriorly or with none

Family CHAETONOTIDAE

Rear end forked; with one pair of cement tubes

Three genera — *Lepidoderma*
Chaetonotus
Ichthydium

Family DASYDYTIDAE

Rear end rounded; no cement tubes

One genus — *Dasydytes*

OUTLINE OF CLASSIFICATION OF THE ROTATORIA
(or *Rotifera*)

Class BDELLOIDEA

With paired ovaries; no male animals

Family ADINETIDAE

Corona flat, with cilia on the ventral side

Common genus — *Adineta*

Family PHILODINAVIDAE

No corona;with a bunch of cilia in the mouth region

Common genus — *Philodinavus*

Family PHILODINIDAE

Corona in the form of two very distinct rings of cilia

Common genera — *Philodina*
Rotaria
Habrotrocha

Class MONOGONONTA

With one ovary; with both male and female animals

Order FLOSCULARIACEA

With cilia in two rings around the corona, those of the inner ring longer; with or without a foot ending in a ciliated disc

Family FLOSCULARIIDAE

Single or colonial; usually attached, living in a tube, or with spines or branched appendages; with or without a foot ending in a cliliated disc

Common genera — *Floscularia*, *Octotrocha*, *Limnias*, *Ptygura*, *Filinia*, *Pedalia*, *Simantherina*, *Lacinularia*

Family CONOCHILIDAE

Free-swimming colonies

Common genus — *Conochilus*

Family TESTUDINELLIDAE

Free-swimming individuals; either spherical or with a foot ending in a ciliated disc

Common genera — *Testudinella*
Trochosphaera

Order COLLOTHECACEA

Attached or living in a tube; with or without a foot ending in a ciliated disc; mouth in the center of a large corona

Family COLLOTHECIDAE

Usually with long bristles, which move slowly instead of beating rapidly like ordinary cilia

Common genera — *Collotheca*
Stephanoceros

Family ATROCHIDAE

No setae or cilia around the corona

Common genera — *Atrochus*
Cupelopagis
Acyclus

Order PLOIMA

Single; free-swimming; with or without a foot ending in one or more toes; corona not as in the preceding two orders

Family NOTOMMATIDAE

No lorica; no bristles or projections from the corona; foot projecting squarely posteriorly

Common genera — *Notommata* *Eosphora*
Taphrocampa *Cephalodella*
Proales *Monommata*
Pleurotrocha

Family DICRANOPHORIDAE

Similar to the preceding family, but with two eyes in the neck; often grouped with the preceding family

Common genus — *Dicranophorus*

Family TRICHOCERCIDAE

Lorica entire, often asymmetrical; with one toe or two unequal toes or two equal, short toes

Common genera — *Trichocerca*
D.urella

Family CHROMOGASTRIDAE

Lorica regularly outcurved, of two convex plates; no foot

Common genus — *Chromogaster*

Family TRICHOTRIIDAE

Lorica entire; foot and toes about as long as the body or lorica with long dorsal spines

Common genera — *Trichotria*
Macrochaetus
Scaridium

Family MYTILINIDAE

Lorica with three or four plates

Common genus — *Mytilina*

Family ASPLANCHNIDAE

Sac-like; intestine usually absent; foot absent or small and projecting from the rear of the ventral side

Common genera — *Asplanchna*
Asplanchnopus

Family SYNCHAETIDAE

Corona with several long bristles; with or without paddle-like appendages; no lorica; with or without a foot

Common genera — *Synchaeta*
Polyarthra

Family PLOESOMIDAE

Lorica with a mid-ventral split; foot ringed, very retractile, projecting ventrally

Common genus — *Ploesoma*

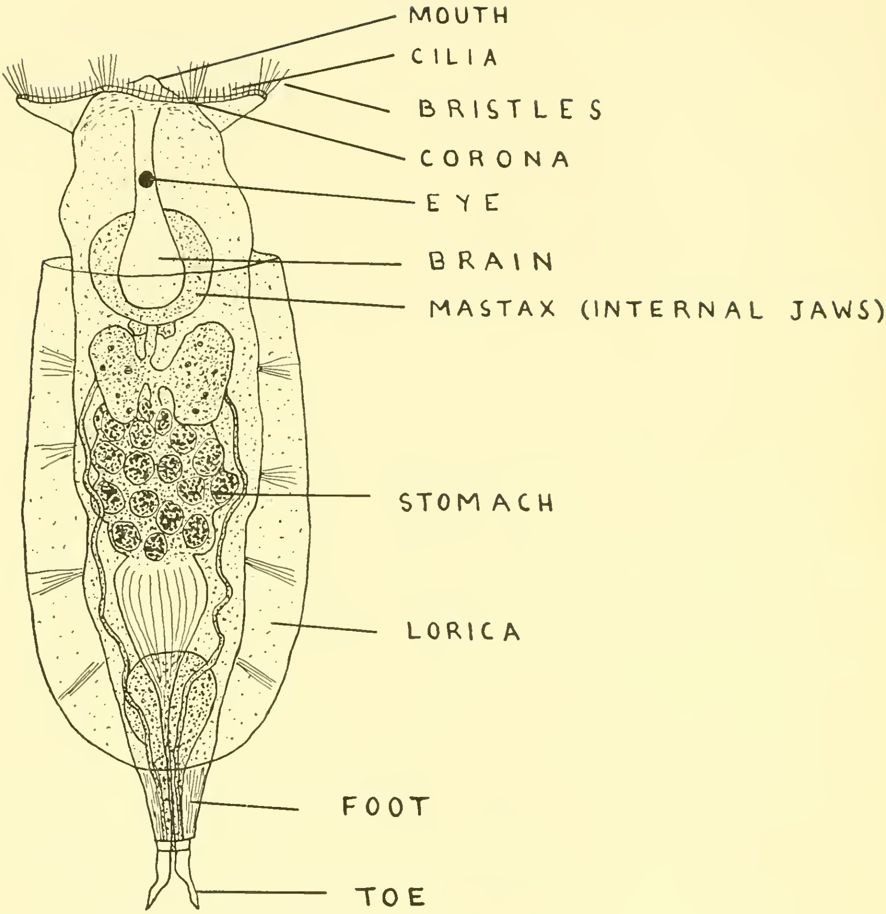


DIAGRAM OF A ROTIFER

DORSAL VIEW

Family GASTROPODIDAE

With entire lorica; foot ringed, very retractile, projecting ventrally

Common genus — *Gastropus*

Family MICROCODONIDAE

Mouth in center of the corona (and so often placed under Order *Collothecacea*); no lorica; with one toe or two unequal toes

Common genera — *Microcodon*
Mikrocodides

Family BRACHIONIDAE

A large and varied group which has been variously divided into other families by different writers; with or without a lorica of one or two pieces; with or without a foot; corona with or without bristles or projections; mastax malleate (all parts well developed, for grinding and for prehension)

Common genera — *Epiphanes*, *Cyrtonia*, *Brachionus*, *Schizocerca*, *Platyias*, *Squatinella*, *Keratella*, *Notholca*, *Euchlanis*, *Lecane*, *Monostyla*, *Lapadella*, *Colurella*

KEY TO THE PRINCIPAL GENERA OF ROTIFERS AND GASTROTRICHA

1. Body usually flattened; without internal jaws; with two tufts of bristles on each side of the head, or head with long spines—
GASTROTRICHA 2.
Body usually, but not always, sac-like or tubular, sometimes colonial; animal transparent, with internal jaws (mastax); usually, but not always, with one or more rings of cilia in the area of the mouth
ROTIFERA 5.

2. Rear end rounded
Dasydytes Gosse
Rear end forked 3.

3. Skin smooth
Ichthydium Ehrenberg
Skin with scales or spines 4.

4. Skin with diamond-shaped scales; caudal projections jointed
Lepidoderma Zelinka

Skin with rounded scales or spines, or both; rear projections plain
Chaetonotus Ehrenberg

5. Apparently permanently attached or in colonies or living in a tube 6.
Temporarily attached or separate, free-swimming or creeping individuals; almost always without a tube 15.

6. In spherical colonies 7.
Not so 9.

7. Colonies free-swimming
Conochilus Ehrenberg
Colonies attached 8.

8. Animals embedded in a mass of jelly
Lacinularia Schweigger
Not so
Sinantherina Bory
(*Megalotrocha* Ehrenberg)

9. No cilia or setae around the corona, although sometimes a ring of cilia around the body below the corona 10.
With cilia or setae around or on the corona 11.

10. Body fat and sac-like; corona cup-shaped
Cupelopagis Forbes
(*Apsilus* Metschnikoff)
Body narrow; corona with one long, sickle-shaped lobe
Acyclus Leidy

11. Usually with long bristles, instead of cilia, which move slowly instead of beating rapidly like ordinary cilia 12.
With cilia in two rings around the corona, those of the inner ring longer 13.

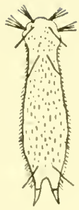
12. Corona in the form of five long, slender projections bearing bristles
Stephanoceros Ehrenberg
Corona plain or lobed, but not drawn out into slender projections
Collotheca Harring
(*Floscularia* Oken)

13. With three or four lobes in the corona
Floscularia Cuvier
(*Melicerta* Schrank)
Corona nearly circular or in two lobes 14.

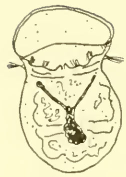
14. Corona almost circular
Ptygura Ehrenberg
(*Oecistes* Ehrenberg)
Corona with two very distinct lobes
Limnias Schrank

15. Animal almost or quite spherical, without a foot
Trochosphaera Semper
Not so 16.

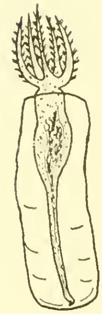
16. With a lorica (or stiff or rigid and usually transparent sheath) 17.
No lorica 39.



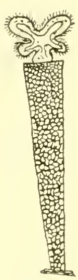
CHAETONOTUS



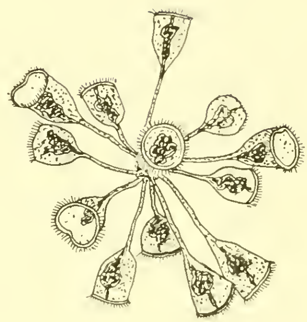
CUPELOPAGIS



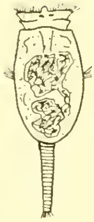
STEPHANOCEROS



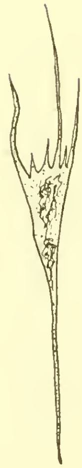
FLOSCULARIA



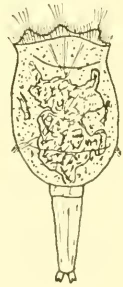
CONOCHILUS



TESTUDINELLA



NOTHOLCA



BRACHIONUS

17. Without a foot, but often wth a rear projection of the lorica 18.
With a foot 20.

18. Lorica outcurved all around
Chromogaster Lautenborn
(*Anapus* Bergendal)
Lorica flattened on one side 19.

19. Lorica with lengthwise ridges or furrows
Notholca Gosse
Lorica irregularly marked
Keratella Bory
(*Anuraea* Ehrenberg)

20. Foot ending in a ring of cilia
Testudinella Bory
(*Pterodina* Ehrenberg)
Foot not so, being forked or ending in one or two toes 21.

21. Foot deeply forked, each fork bearing two short toes
Schizocerca Daday
Foot with one or two toes 22.

22. Foot with many short rings, very retractile 23.
Foot with a very few wide segments, not much retractile 25.

23. Foot projecting from the rear of the body
Brachionus Pallas
Foot projecting from the rear of the ventral side 24.

24. Lorica wrinkled
Ploesoma Herrick
Lorica smooth
Gastropus Imhof.

25. Foot ending in one toe or in one long toe and one very short toe 26.
Foot ending in two equal toes or in one long toe and one shorter toe which is about one-half or more the length of the long toe 27.

26. Lorica divided into lengthwise plates; with one toe
Monostyla Ehrenberg
Lorica almost plain; with one long toe and one very short, scarcely noticeable toe
Trichocerca Lamarck
(*Rattulus* Lamarck)

27. Lorica in one almost cylindrical piece 28.
Lorica composed of two to four lengthwise plates, often flattened 32.

28. Dorsal surface of lorica with long spines
Macrochaetus Perty
(*Polychaetus* Perty)
No spines on dorsal surface of lorica 29.

29. With a flat, chitinous plate above the head
Squatinella Bory
(*Stephanops* Ehrenberg)
No plate above the head 30.

30. Foot and toes short; toes sometimes unequal
Diurella Bory
(*Coelopus* Hudson and Gosse)
Foot and toes about as long as the body; toes equal 31.

31. Lorica almost smooth
Scaridium Ehrenberg
Lorica marked into irregular sections
Trichotria Bory
(*Dinocharis* Ehrenberg)

32. With a chitinous plate above the head, which is arched in side view, appearing like a sickle 33.
No plate over head 34.

33. Lorica higher than wide, of two side plates
Colurella Bory
(*Colurus* Ehrenberg)
Lorica wider than high, of one dorsal and one ventral plate
Lepadella Bory
(*Metopidia* Ehrenberg)

34. Lorica split down the back, of three or four plates 35.
Lorica composed of one dorsal and one ventral plate 36.

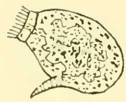
35. Lorica small, covering only the upper part of the body
Diaschiza Gosse
Lorica enclosing the body; usually, but not always, with spines projecting forward
Mytilina Bory
(*Diplax* Gosse)
(*Salpina* Ehrenberg)

36. Foot with one segment 37.
Foot with three segments 38.

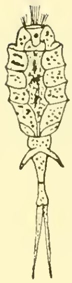
37. Corona somewhat narrower than the body; toes usually longer than the rest of the foot
Lecane Nitzsch
(*Cathypna* Gosse)
(*Distyla* Eckstein)
Corona about as wide as the body; toes very short
Brachionus Pallas

38. Body fat; corona almost as wide as the body
Platyias Harring
(*Noteus* Ehrenberg)
Body lengthened; corona about half as wide as the widest section through the body
Euchlanis Ehrenberg

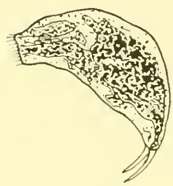
39. Body cylindrical, formed of ring-like segments which may be drawn up within one another; usually, but not always, with three toes; swimming or creeping; with or without a corona 40.
Body not so; with or without a foot with one or two toes; swimming only; with a corona 44.



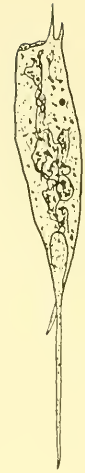
GASTROPUS



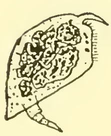
TRICHOTRIA



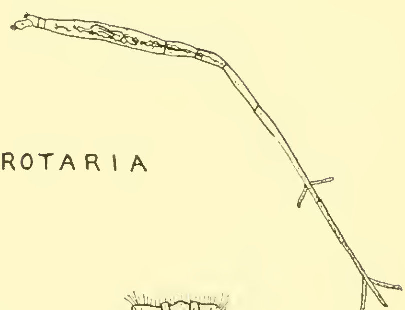
DIURELLA



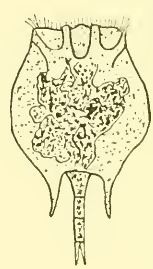
TRICHOCERCA



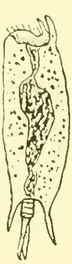
COLURELLA



ROTARIA



PLATYIAS



MYTILINA

40. No corona; only a bunch of cilia about the mouth
Philodinavus Harring
(*Microdina* Murray)
With one or more rings of cilia 41.

41. Corona flat, regular
Adineta Hudson
Corona in the form of two very distinct rings of cilia 42.

42. No eyes
Habrotrocha Bryce
(*Callidina* Ehrenberg)
With two eyes 43.

43. Eyes far back in the neck
Philodina Ehrenberg
Eyes very near the front
Rotaria Scopoli
(*Rotifer* Cuvier)

44. No foot 45.
With a foot 50.

45. With spines or jumping or swimming appendages 46.
Body sac-like, without appendages 48.

46. With two or three spines
Filinia Bory
(*Pedetes* Gosse)
(*Triarthra* Ehrenberg)
With several branched or paddle-like appendages 47.

47. Appendages branched
Pedalia Barrois
(*Pedalion* Hudson)
Appendages paddle-like
Polyarthra Ehrenberg

48. Corona with two to four long bristles and wider than the body
Synchaeta Ehrenberg
Corona without bristles, a little narrower than the body 49.

49. Body transparent
Asplanchna Gosse
Body colored or opaque
Ascomorpha Perty

50. Mouth in the center of the corona; with one toe or with two very unequal toes placed one dorsal to the other 51.
Mouth not in the center of the corona; with two equal or nearly equal toes side by side 52.

51. Foot about as long as the body; eye usually purple
Microcodon Ehrenberg
Foot shorter; eye usually red
Mikrocodides Bergendal

52. Corona with a few long bristles, or else with bunches of bristles alternating with the cilia of the inner ring 53.
No bristles on the corona 55.

53. With two to four long bristles on the corona
Synchaeta Ehrenberg
With bunches of bristles in the inner ring of cilia 54.

54. No eye, or else body sac-like
Epiphanes Ehrenberg
(*Notops* Hudson)
(*Hydatina* Ehrenberg)
With one eye; body tapering; with a hump on one side
Cyrtonia Rousselet

55. Foot projecting from the rear of the ventral side of the body 56.
Foot projecting squarely posteriorly 57.

56. Back almost flat
Asplanchnopus de Guerne
With a decided hump on the back
Enteroplea Ehrenberg
(*Triphylus* Hudson)

57. No eyes
Pleurotrocha Ehrenberg
With one to three eyes 58.

58. With one eye 59.
With two or three eyes 62.

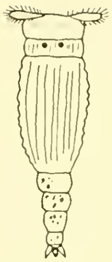
59. Eye near the front
Monommata Bartsch
(*Furcularia* Ehrenberg)
Eye in the neck 60.

60. Skin with many cross folds permanently fixed
Taphrocampa Gosse
Skin not so, although sometimes jointed 61.

61. Corona regular
Proales Gosse
With a lobe bearing longer cilia on each side of the corona; these lobes (auricles) are usually contracted and not visible when the animal is not swimming
Notommata Ehrenberg
(Includes *Copeus* Gosse)

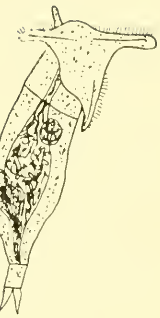
62. With three eyes
Eosphora Ehrenberg
With two eyes 63.

63. With a dorsal projection from the corona bearing two eyes
Rhinoglena Ehrenberg
(*Rhinops* Hudson)
No dorsal projection from the corona 64.

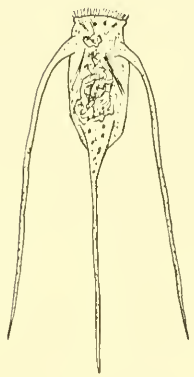


PHILODINA

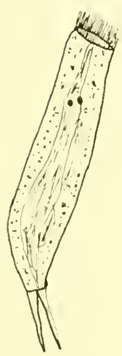
PEDALIA



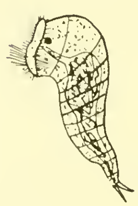
NOTOMMATA



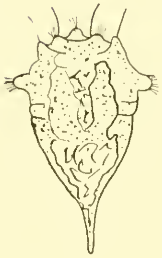
FILINIA



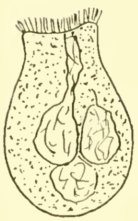
DICRANOPHORUS



CYRTONIA



SYNCHAETA



ASPLANCHNA

64. Eyes in the neck
Dicranophorus Nitzsch
(*Distemma* Ehrenberg)
Eyes near the front margin
Cephalodella Bory
(*Diglena* Ehrenberg)

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The names used as first choice in the Rotifer Key are those given in Harring's "Synopsis of the Rotatoria".

WORM-LIKE AND LEECH-LIKE ANIMALS

Chapter 5

When Linnaeus, in the eighteenth century, was developing the system of classification upon which our modern system is based, he grouped a large number of soft-bodied invertebrates into one division which he called *Vermes* or Worms. This tendency to call any creeping invertebrate a worm still persists among the general public, and caterpillars are called cabbage worms or measuring worms even by people who know them to be insect larvae. As scientific knowledge increased, more and more animals were taken out of Linnaeus' group of *Vermes*. At the present time the naturalist acknowledges three main groups of land and fresh-water worms, which constitute three phyla in our modern system. These are the *Platyhelminthes* or Flatworms, the *Nemathelminthes* or Round Worms and the *Annelida* or *Coelhelminthes*, the Segmented Worms. Another small group, the *Nemertea*, are sometimes placed with the *Platyhelminthes*. The *Rotifera* also are sometimes grouped as *Vermes*, but are here treated in a separate chapter.

Some other forms in our ponds look very much like worms, and the amateur is often deceived by them. Several of the insect larvae, especially the midges, have a strong resemblance to the bristle worms or aquatic annelids, but may be distinguished by their distinct heads. On land, the slugs are often mistaken for worms. These are in reality shell-less mollusks, distinguished by two pairs of tentacles and by the mantle which covers part or all of the back.

The flatworms are best known for the more disreputable of their number, the parasitic flukes or tapeworms. Most North American free-living forms are small and inconspicuous, seldom becoming more than an inch or two in length. They are finely ciliated animals, called *Turbellaria* from the currents which their cilia set up in cloudy water. The cilia themselves are not apparent, but the animals appear to move by a steady, effortless, gliding motion. Whenever pond weeds are brought in for the aquarium or for the study of their animal guests, some *Turbellaria* are likely to be found. An investigation of the under sides of submerged rocks or logs is also likely to reveal some of these tiny, flattened creatures. The largest ones might be mistaken for leeches, but they do not have the posterior adhesive discs possessed by leeches. A few live in moist places on land and may sometimes be found in greenhouses or under boards in damp corners of gardens.

One of the peculiarities of the *Turbellaria* is the position of the mouth, which is situated in the middle of the ventral surface. From the mouth a long, tube-like pharynx can be protruded to take in particles of food. The digestive tract extends into all parts of the body and has either three main branches, one anterior and two posterior to the mouth, or else a modification of one large sac, which may divide into a complex arrangement of many small branches. These branches can often be seen through the body wall, especially if they are distended with food of a color different from that of the body.

The *Turbellaria* show extreme powers of regeneration. One of the common genera, *Dugesia,* has been widely used in experimental laboratories. Dr. Child has shown that even a fragment consisting of as little as one-two hundred and fiftieth of the original animal can still replace the missing parts and form a complete animal. In its natural state the creature frequently breaks into two of its own accord, and each part regenerates the portions it lacks. Eggs are also produced at certain seasons of the year.

Until recently the larger *Turbellaria* of Europe and America were supposed to be very closely related, if not actually the same species. Studies of their internal anatomy now seem to indicate that there are important differences. The familiar name *Planaria* is now reserved for European forms, and our American forms are called *Dugesia* or other new generic names.

The *Nemathelminthes* or Round Worms have neither the gliding motion of the flatworm nor the segmentation of the ringed worm. Their motion is snake-like, their form thread-like. The tiny or microscopic members of the group have received the popular appellation of "nemas". The nemas most widely known, until modern methods of merchandising developed, were the "vinegar eels". As a matter of fact, nemas are universally present almost everywhere life of any form can exist, from arctic ice to tropical jungles. They are often parasitic on plants and cause damage in greenhouses and nurseries.

Another famous member of the Round Worm group is the Horsehair Snake. Many a farm boy has seen these undulating "serpents" swimming in the watering trough and has never doubted that, in some miraculous way, some hairs from Dobbin's tail have become endowed with life. It is a pity that *Gordius* (Linnaeus named the animal after the classic Gordian knot which even Alexander could not untie) has no press agent of his own, for his true life is even more remarkable than his legendary one. Starting his career as a parasite in the intestine of some insect, commonly a grasshopper, he travels *a la Jonah* all summer and finally, leaving his dying host, he emerges for a free-living adult life in some pond or stream. Really quite common in our smaller bodies of water, the little Gordian knot progresses very slowly and, if noticed at all, is mistaken for a fine rootlet moving with the current.

The larger and usually terrestrial members of the *Annelida* or Ringed Worms are familiar to all of us, if only in the form of fish bait or as prey for the robins on our lawns. In addition, there are hosts of smaller and more active ones in the ponds and streams. The worm as we usually meet him is a degenerate, specialized and unappealing animal. To appreciate segmented worms properly one must see their marine relatives, which have retained definite heads, often with biting or pinching jaws and sometimes a shock of "hair" or tentacles, and along whose sides are rows of paddle-like structures, called parapodia, serving as both legs and gills. The heads of the land and fresh-water forms are almost non-existent and the parapodia are represented only by tiny bristles or setae, which aid the worms in their movements or enable them to resist the tug of the early bird. The only external character at all noticeable in the adult earthworm is the clitellum, a thickened area somewhere between the twelfth and the thirty-fifth segments.

Sexual activity usually begins after the first warm rains of spring and continues through the summer. In the evening, when earthworms mate, each worm emerges from the ground so far that only the tip of its tail remains in its burrow. Then it moves around in search of a neighbor. If it succeeds in finding one, the two lie side by side, head towards tail, and a secretion from the clitellum of each forms a belt around the two. Then, since each worm is both male and female, the two exchange sperm and finally separate. Later the clitellum again becomes active, secreting another belt, this time around the one worm. The worm deposits some of its eggs and some of the sperm it received from its neighbor within this secretion of the clitellum. It then backs out of this belt, which closes down on eggs and sperm like a section of elastic tubing and forms the cocoon in which the young worms develop.

The small aquatic annelids usually have long setae or bristles projecting from the body and so are commonly called Bristle Worms. It is necessary to make out the details of these bristles in order to identify these worms, and some difficulty is caused by the fact that some of the bristles may be retractable. A weak solution of glycerine as a mounting fluid is helpful in slowing down the activities of a worm and enabling one to study it from all sides. Some of the aquatic annelids reproduce sexually. Others reproduce by fission. A constriction appears in the mid-region of the body, a head develops behind this constriction, and soon two worms appear in place of one.

The part worms play in human affairs, aside from those of the fisherman, is seldom appreciated. Charles Darwin's book, *The Formation of Vegetable Mould, Through the Action of Worms*, is a revelation to most readers and gives astounding facts on the immense worm population of fields, the utility of worms in maintaining soil fertility, and even their value to the archaeologist in preserving the ruins of antiquity.

Leeches or blood suckers are common in most ponds and streams but, fortunately for our peace of mind, few of them seek human blood. Some of them are not even parasitic, but feed on small animals and plant material. They may be distinguished from all other aquatic animals by their sucking discs, one at each end; by their appearance of extreme segmentation, since each somite is superficially subdivided into several; and usually by their flattened bodies. Unlike the earthworms, most of the leeches have retained eyes and jaws.

For centuries leeches have been used for medicinal purposes. In the nineteenth century "leech" was a common synonym for *doctor.* Disease was regarded as due to "bad blood", which needed to be removed, so that "good" blood could be formed in its place. The more heroic patients patronized the barber-surgeons, with their lancets and bleeding cups, and the barber's sign of the red-and-white striped pole is said to refer to the blood and bandages. The less courageous used leeches to remove the blood painlessly and less visibly. Napoleon's surgeon-general popularized the use of large numbers at a time, recommending a "cordon of leeches" on the forehead for headache. The local supply running short, France imported leeches by the million from Russia, until even that country had to protect its supply by a law forbidding the taking of leeches during the three summer months when they were breeding. In most European countries leech ponds were built to propagate the animals, and fancy china "leech jars" were available so that each family might keep its medicine chest stocked with live leeches. The three sharp jaws of the leech make a painless, triangular incision, into which it pours a secretion which inhibits the clotting of blood. The medicinal leech of Europe, imported into America for medical purposes and now naturalized in some areas, is capable of taking from one-half to one ounce of blood at a feeding. The best our native ones can do is about one-fifth of an ounce. When the leech has completed its meal, it drops off. Since it has also withdrawn the anticlotting substance, the wound usually gives no trouble. If the leech be removed before it has finished its meal, the wound may continue to bleed for a long time.

Leeches, like earthworms, reproduce sexually. The eggs are usually deposited in cocoons formed by bodily secretions and fall to the bottom of the pond, where they develop into young leeches. The *Glossiphonidae* bear their eggs and later their young attached to the ventral surface. Most leeches are hermaphroditic.

Collection of Earthworms

The larger Lumbricid worms can be collected in quantity on spring nights during or after evening thunder-showers or warm rains. At this time the worms extend most of their bodies from their burrows in search of mates. Most well established lawns prove to be good hunting fields. A small flashlight should be used, or the lens covered with red cellophane, as a bright light alarms the worms, which then snap back into their burrows as though they were stretched rubber bands. A quick grab must be made, for if the worm gets any warning it will brace itself with its setae and the collector will get only a portion or a damaged worm. Heavy rains often flood many of the smaller earthworms from their burrows, even in daylight. Old manure piles, compost and rotting leaves often harbor several species. If the collector does not care for digging, he may use some of the chemical compounds sold for use on golf courses. These chemicals are soaked into the soil, and often bring up the worms with surprising speed. Worms collected by this method can rarely be kept alive afterward, however.

Care and Preparation of Earthworms

Worms collected for scientific study are usually kept alive for several days in sphagnum moss or damp cheesecloth or muslin, in order that their intestines may be emptied of soil, which might prevent the making of good dissections or the cutting of sections. They are usually anaesthetized by placing them in water to which a little chlorotone has been added, or in water to which alcohol is added at intervals until about 10% is reached. Then, when fully relaxed, they should be washed free of mucus, transferred to fresh 10% alcohol for several hours, then to 40%, 70% and 95% alcohol. After a day or so they may be put in 70% alcohol for storage. If the collector has some technical experience, he will find that injection with 1% aqueous solution of chromic acid following the 10% alcohol bath will produce excellent results. If one expects to section them later, the worms should be transferred from the 10% alcohol to one of the standard fixing fluids, such as Bouin's or Zenker's and the usual procedure followed.

In the case of some earthworms, unfortunately, the lack of definite external characters makes it necessary for one to examine the internal organs in order to determine genera. To accomplish this the worm should be stretched out, dorsal side up, on a piece of soft wood or cardboard, and the skin carefully cut, with fine-pointed scissors, along the mid-dorsal line. The skin can then be turned back on either side and pinned to the board, so that an unobstructed view of the internal organs is possible.

OUTLINE OF CLASSIFCATION OF WORM-LIKE AND LEECH-LIKE ANIMALS

Phylum PLATYHELMINTHES

Usually flattened worms without segmentation or body cavity

Class TURBELLARIA

Free-living flatworms with ciliated epidermis

Order RHABDOCOELIDA

With simple tube or sac-like intestine without lateral branches

Order TRICLADIDA

Intestine trilobed, one lobe anterior to pharynx and two posterior, with simple or branched diverticula

Suborder HAPLONEURA (or *Paludicola*)

Aquatic; intestine lobes usually with branched diverticula

Suborder DIPLONEURA (or *Terricola*)

Terrestrial; diverticula simple-branched

(Phylum) NEMERTEA (sometimes regarded as a class under Phylum *Platyhelminthes*)

With an eversible proboscis above the anterior part of the digestive tract; epidermis ciliated; anus present; no external segmentation

(Class) HOPLONEMERTEA

Proboscis partly eversible, armed with one or more dagger-like stylets

Phylum NEMATHELMINTHES

Cylindrical animals with no external segmentation; ectoderm covered with a thick cuticle; no cilia

Class NEMATODA

With lengthwise, internal, lateral, muscular ridges; digestive tract functional in most but not all families

Class GORDIACEA (or *Nematomorpha*)

No lateral, muscular ridges; digestive tract non-functional and often incomplete in adult

Phylum ANNELIDA (or *Coelhelminthes*)

Segmented or metameric externally and internally; with coelom, or body cavity

Class POLYCHAETA

With parapodia and setae

Class OLIGOCHAETA

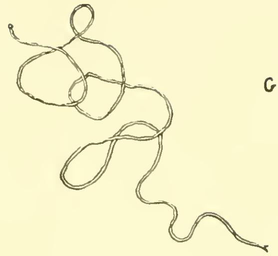
With setae but no parapodia

Class HIRUDINEA

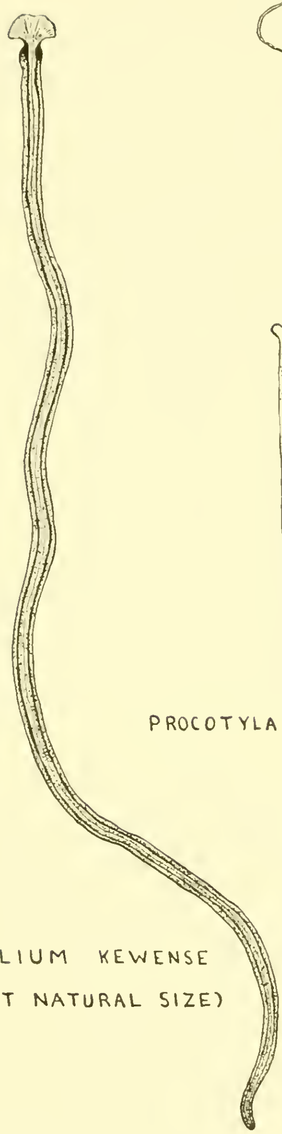
No parapodia or setae; with a sucking disc around the mouth and usually another at the posterior end of the body; with more external rings than true segments

KEY TO THE PHYLA OF WORM-LIKE AND LEECH-LIKE ANIMALS

1. Animals minutely ciliated; moving with a gliding or flowing motion 2.
   Animals not ciliated (often with setae or bristles); usually moving with a writhing or hitching motion 3.
2. Mouth, from which a long proboscis may be protruded, situated at the anterior end; digestive tract tubular, running the length of the body; getting to be three-quarters of an inch long; color reddish
   NEMERTEA—one species in fresh water



GORDIUS – MALE
(ABOUT NATURAL SIZE)



BIPALIUM KEWENSE
(ABOUT NATURAL SIZE)

PROCOTYLA FLUVIATILIS DUGESIA MACULATA
(BOTH ENLARGED)

THE VINEGAR EEL – A NEMA
(MAGNIFIED)

Prostoma rubrum (Leidy)
(*Stichostemma rubrum* (Leidy))

Mouth without a proboscis and situated somewhat back from the anterior end, frequently in the middle of the ventral side; digestive tract modified sac-like; size various; color various
PLATYHELMINTHES—*Turbellaria* Flatworms

3. Body segmented
ANNELIDA Annelids

Body not segmented
NEMATHELMINTHES Round Worms

KEY TO THE COMMON NEMATHELMINTHES OR ROUND WORMS

1. Usually minute forms living in soil, on vegetation, etc.; intestine complete (Very difficult to identify. The genera are not included here.)
Class *Nematoda* Thread Worms or Nemas

Parasitic, usually in insects, as young; free-living as adults; getting to be several inches long; digestive tract often somewhat degenerate in the adult 2.

2. Cuticle usually finely striate; posterior end pointed; digestive tract usually degenerate posteriorly; free-living in water, soil or on vegetation
Family *Mermithidae* of Class *Nematoda*
Mermis Dujardin (typical genus) "Cabbage Worms"

Cuticle usually rugose; posterior end split or bluntly rounded; digestive tract often degenerate anteriorly; free-living in water—Class *Gordiacea* Hair Worms 3.

3. Anterior end rounded, usually with a narrow, dark ring just back from the tip; posterior end rounded (in female) or split into two tips (in male)
Gordius Linn.

Anterior end oblique or pointed; posterior end rounded or split into two or three tips 4.

4. Anterior end oblique, with a wide, dark ring just back from the tip; posterior end split into two (in male) or three (in female) tips
Paragordius Camerano

Anterior end pointed, without a dark ring; posterior end not split, but rounded (somewhat coiled in male, swollen in female)
Chordodes Creplin

THE FREE-LIVING FLATWORMS OR TURBELLARIA

1. Intestine simple, modified sac-like, sometimes dividing into many small branches; animals usually minute (Keyed mainly on internal characters and very difficult to identify. The genera are not included in this key.)
Order *Rhabdocoelida* Smaller Water Turbellaria

Intestine with three branches, one median anterior and two lateral posterior; usually small but not as minute as the preceding—Order *Tricladida* 2.

2. Land animals—The *Diploneura* (*Terricola*) Land Turbellaria 3.
Water animals—The *Haploneura* (including the *Paludicola*) Larger Water Turbellaria 7.

3. Body ribbon-like, with the head suddenly wider than the body; getting to be several inches long; found in greenhouses
Bipalium kewense Moseley Ribbon Worm
(*Placocephalus kewense* (Moseley))
Animal tapered at each end; smaller 4.

4. With many eyes in linear arrangement around the anterior margin and back along the sides; getting to be an inch or more long; Cal. into Mexico
Geoplana mexicana Hyman
With a pair of eyes anteriorly, or eyes apparently absent; less than an inch long 5.

5. First fifth of animal narrower and more cylindrical than the rest; usually lengthwise striped; reported from Pa. and Ohio
Rhynchodemus sylvaticus (Leidy)
Animal more evenly tapering at each end; more uniformly grayish 6.

6. Eyes apparently absent; W. Va. to Maryland
Diporodemus indigenus Hyman
Eyes more apparent; Ky to Mo.
Geodesmus atrocyaneus (Walton)
(*Rhynchodemus atrocyaneus* (Walton))

7. With many eyes in an inverted U-shaped arrangement around the front and sides of the head region; found in the southwest
Polycelis coronata (Girard)
Eyes none to several in pairs or in two lengthwise rows 8.

8. No eyes; color white; cave species 9.
With eyes; color various 13.

9. With many pharynxes; Indiana
Phagocata subterranea Hyman
With one pharynx from the middle of the ventral surface 10.

10. With pointed head lobes; Kentucky
Sphalloplana percoeca (Packard)
(*Dendrocoelum percoecum* Packard)
Head lobes obscure or absent 11.

11. Animal turtle-shaped, with a snout about one-fourth as long as the body; small (about one-eighth of an inch long); Oregon
Kenkia rhynchida Hyman
Animal flattened, elongate, tapering posteriorly; larger 12.

12. With a short snout visible only when the animal is contracted; Penn.
Speophila pricei Hyman
No snout; Kentucky
Speophila buchanani Hyman

13. Anterior end truncate 14.

Anterior end pointed or narrowly rounded 19.

14. With an adhesive circle in the middle of the anterior margin; eyes two to several, near the front and well separated; color white
Procotyla fluviatilis Leidy
(*Dendrocoelum lacteum* Oersted)
No adhesive circle; with two eyes farther back and closer together; color various 15.

15. Color white 16.
Color gray or black 17.

16. With one pharynx from the middle of the ventral side
Phagocata morgani (Stevens & Boring)
(*Fonticola truncata* (Leidy))
With several pharynxes; Indiana
Phagocata subterranea Hyman

17. Color gray; with one pharynx from the middle of the ventral side
Phagocata velata (Stringer)
Color gray to black; with several pharynxes 18.

18. Head lobes conspicuous
Phagocata gracilis (Haldeman)
Head lobes less evident
Phagocata woodworthi Hyman

19. Head lobes slender and acutely pointed; anterior end sharply pointed; large (to one inch), active animals 20.
Head lobes thick and bluntly pointed; anterior end more rounded; smaller, sluggish animals 21.

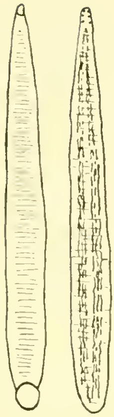
20. Dark above and below
Dugesia agilis (Stringer)
(*Euplanaria agilis* (Stringer))
Brown above, lighter below
Dugesia dorotocephala (Woodworth)
(*Euplanaria philadelphica* Hyman)

21. With scattered, unpigmented areas on a grayish or purplish background
Dugesia tigrina (Girard)
(*Euplanaria maculata* (Leidy))
(*Planaria lata* Sivickis)
Uniformly dark colored above 22.

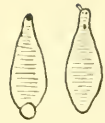
22. Head lobes obscure; color usually blackish
Curtisia foremanii (Girard)
(*Planaria simplissima* Curtis)
(*Planaria lugubris* Schmidt)
Head lobes evident; color usually brownish
Dugesia microbursalis (Hyman)
(*Euplanaria microbursalis* Hyman)

KEY TO THE PRINCIPAL GENERA OF ANNELIDS, INCLUDING SOME OF THE COMMON SPECIES OF LEECHES AND EARTHWORMS

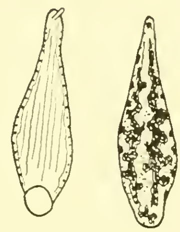
1. With a sucker on the posterior end of the body (often difficult to see);



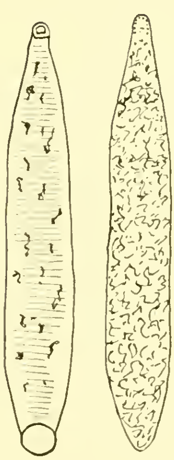
HERPOBDELLA PUNCTATA



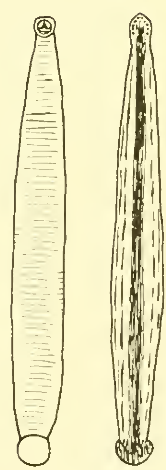
GLOSSIPHONIA STAGNALIS



PLACOBDELLA PARASITICA



HAEMOPSIS MARMORATIS



HIRUDO MEDICINALIS

no setae; body usually stout; semi-parasitic animals, often found free 2.
No sucker on the posterior end; with setae; body usually slender 40.

2. No sucker on the anterior end; parasitic on crayfishes; Family *Discodrilidae* or *Branchiobdellidae* of Class *Oligochaeta* 3.
With a sucker on the anterior end; Class *Hirudinea* or Leeches 10.

3. Back with projections or raised cross bars 4.
Not so 5.

4. Back with rough, raised, cross bars
Cirrodrilus Pierantoni
With large, upright projections along the mid-dorsal line
Pterodrilus Moore

5. Posterior end flat and wide, so that the body is spade-shaped
Xironogiton Ellis
Not so 6.

6. Body flattened; posterior sucker on the under side of body
Xironodrilus Ellis
Body cylindrical; posterior sucker at the end of body 7.

7. With most of the main body segments subdivided into three rings
Triannulata Goodnight
Not so 8.

8. Head very distinct from the body; with one pair of testes in segment five
Branchiobdella Odier
Head less distinct from the body; with two pairs of testes in segments five and six 9.

9. Head narrower than first body segment
Bdellodrilus Moore
Head as wide as or wider than first body segment
Cambarincola Ellis

10. Mouth filling most of the cavity of the anterior sucker; no proboscis 11.
Mouth only a tiny hole in the anterior sucker, from which a proboscis may be projected 22.

11. Without eyes or with three or four pairs of minute eyes not in crescentic arrangement; without jaws—Family *Herpobdellidae* or Worm Leeches 12.
With five pairs of tiny eyes in crescentic arrangement around the anterior end; usually but not always with three jaws, which are often difficult to see—Family *Hirudinidae* or Blood Suckers 15.

12. Body regularly ringed
Herpobdella punctata (Leidy) Common Worm Leech
With each fifth or sixth body ring enlarged 13.

13. With four pairs of eyes; back blotched or plain dark colored
Nephelopsis obscura Verrill
With three or four or no pairs of eyes; back lengthwise striped or almost without pigment and appearing pinkish 14.

14. With lengthwise stripes
Dina anoculata Moore
Pinkish
Dina fervida (Verrill)

15. With three distinct jaws within the mouth area (appearing as opposing ridges or folds) 16.
Jaws not evident, being small, retractile or absent 17.

16. Back greenish, with a central row of red spots and with a row of black spots along each side
Macrobdella decora (Say) Common Northern Blood Sucker
Back greenish, with four to six complete or interrupted lengthwise stripes; an introduced species
Hirudo medicinalis Linn. Medicinal Leech of Europe

17. With three, yellow, lengthwise stripes or with reddish and dark stripes; blood suckers; Gulf states
Philobdella Verrill Southern Blood Suckers 18.
Body blotched, plain dark, or with a yellow stripe along each side; feeding on worms, insect larvae, etc.; not true blood suckers; aquatic or terrestrial or both, typically found on pond edges; widely distributed
Haemopsis Savigny Land and Pond Leeches 19.

18. With a narrow yellow stripe along the middle of the back and with a broader yellow stripe along each side; with brown spots
Philobdella gracile Moore Spotted Southern Blood Sucker
With two dark stripes along the back, each bordered below by a reddish stripe; without spots
Philobdella floridana Verrill Southern Blood Sucker

19. Usually with a median dark stripe and a yellowish stripe along each side
Haemopsis lateralis (Say) Striped Leech
Back dark or blotched; no mid-dorsal stripe but often with a yellowish stripe along each side 20.

20. Back scarcely blotched and about the same shade or lighter than the under side
Haemopsis plumbeus Moore
Back blotched and darker than the under side 21.

21. With very irregular dark blotches on the back
Haemopsis marmoratis (Say) Common Horse Leech
With almost squarish dark blotches on the back
Haemopsis grandis (Verrill) Giant Leech

22. Body usually cylindrical, extremely long and narrow, when extended; stomach with two posterior caeca; usually parasitic on fishes; Family *Piscicolidae* or *Ichthyobdellidae* 23.
Body usually flattened, not so slender; stomach with many lateral caeca; habitat varied; Family *Glossiphonidae* 30.

23. Anterior sucker quite distinct from the body; with pulsating structures along the sides serving as gills 24.
Anterior sucker not distinct from the body; without such pulsating structures. 26.

24. Posterior part of body flatter and wider than anterior part; central body segments (larger divisions of body) composed of about seven small rings
Cystobranchus vividus (Verrill)
(*Trachelobdella vivida* (Verrill))
Body more uniform throughout; central body segments composed of about fourteen small rings. 25.

25. With a line of about ten eye spots along the margin of the posterior sucker
Pisciola milneri (Verrill)
Not so
Pisciola punctata (Verrill)

26. With about three small rings to each segment (larger division of body) near the middle of the body
Piscicolaria reducta Meyer
With twelve to fourteen small rings to each body segment near the middle of the body 27.

27. Body divided into a narrow anterior and a wider posterior region
Illinobdella moorei Meyer
Sides of body more evenly parallel 28.

28. With twelve small rings to each body segment
Illinobdella elongata Meyer
With fourteen small rings to each body segment 29.

29. Body extremely slender, being ten times as long as wide, when extended
Illinobdella richardsoni Meyer
Body less than ten times as long as wide, when extended
Illinobdella alba Meyer

30. With four pairs of simple eyes; color transparent greenish, with yellow spots; parasitic on fish and frogs
Protoclepsis occidentalis (Verrill)
(*Hemiclepsis occidentalis* (Verrill))
With a pair of compound, adjacent eyes or with one to three pairs of simple eyes; color various 31.

31. Some of the body rings noticeably wider than others; fish parasites
Actinobdella annectens Moore
Body practically evenly ringed 32.

32. With one pair of compound, adjacent eyes, with or without pairs of tiny, simple eyes posterior to these; temporary parasites on turtles, frogs, fish, etc.
Placobdella Blanchard (Four common species given) 33.
With one to three pairs of simple eyes; on plants, stones, etc.
Glossiphonia Johnston Brook Leeches (Five common species) 36.

33. With tiny pairs of simple eyes behind the compound eyes; back greenish, mottled with brown, yellow and white; head almost colorless
Placobdella hollensis (Whitman)
With only a pair of compound, adjacent eyes; color various 34.

34. First few segments widened to form a head-like region; back greenish, with lengthwise stripes
Placobdella montifera Moore
No widened head region; striped or blotched 35.

35. With minute, smooth skin papillae; usually greenish, with yellow stripes or spots
Placobdella parasitica (Say) Common Turtle Leech
With sharp skin papillae, usually arranged in lengthwise rows; back blotched green or yellow
Placobdella rugosa (Verrill)

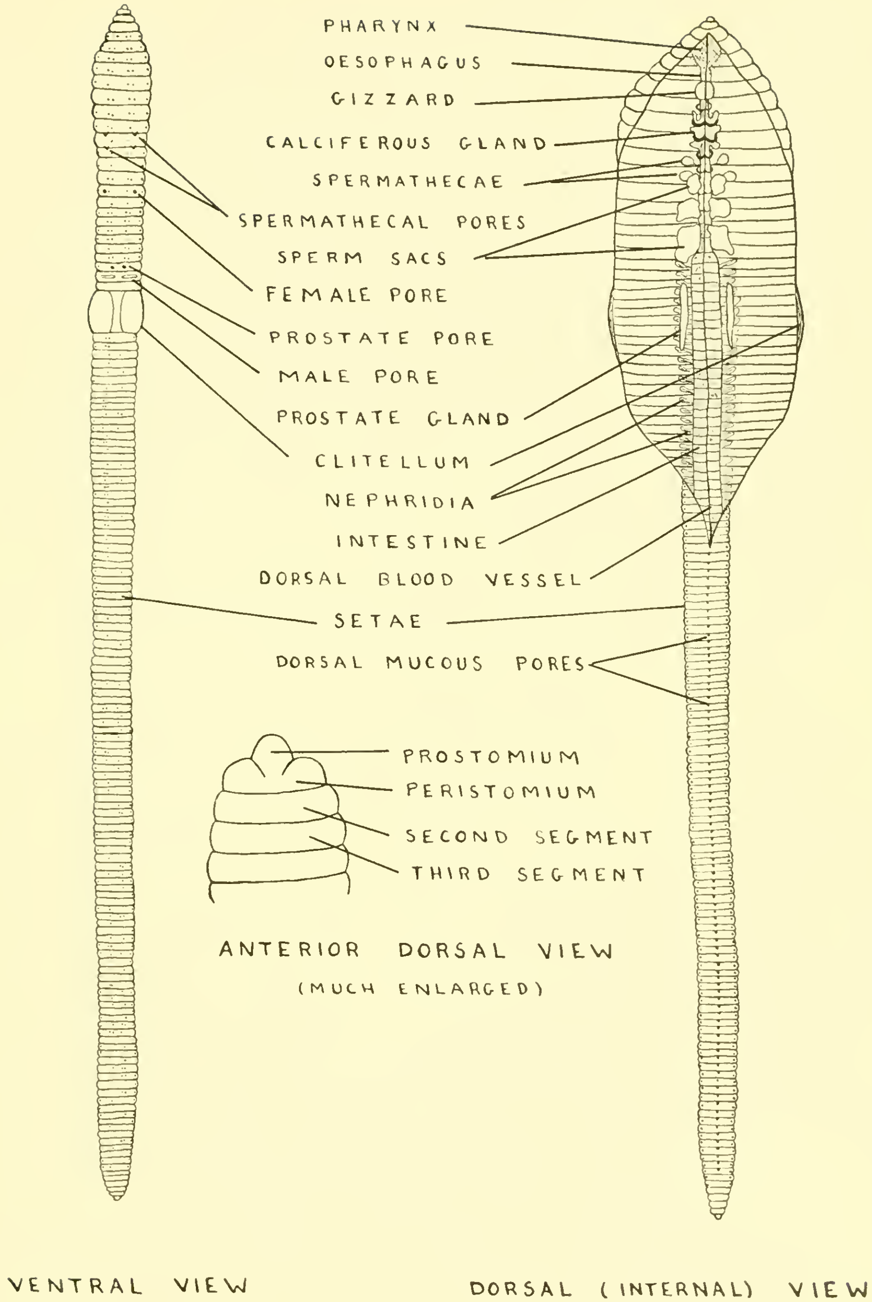


DIAGRAM OF AN EARTHWORM

36. With three pairs of eyes 37.
With only one pair of eyes 38.

37. Back dark, usually with two dark stripes; with two almost parallel rows of eyes
Glossiphonia complanata (Linn.)
Body transparent; with two divergent rows of eyes
Glossiphonia heteroclita (Linn.)

38. Posterior part of body broadened; with many stripes or spots
Glossiphonia fusca Castle
Body very long and narrow; grayish, brownish or almost colorless 39.

39. Grayish or brownish, sometimes transparent; with a brown, horny plate situated between two rings on the back of segment eight
Glossiphonia stagnalis (Linn.)
Transparent, almost colorless; no brown, horny plate so situated
Glossiphonia nepheloidea (Graf)

40. With flattened, leaf-like appendages along the sides of the body, or with head appendages; mostly marine worms, but with two fresh-water genera near the coast — Class *Polychaeta* 41.
Not so — Class *Oligochaeta* 42.

41. With a distinct head and many segments; California
Nereis limnicola Johnston
With about thirty-six gill filaments on an indistinct head area; with twelve segments; animal living in a tube; N. J. and Penna. and in the Great Lakes
Manayunkia eriensis Krecker
(*Manayunkia speciosa* Leidy)

42. Clitellum absent or very narrow, usually beginning on, or anterior to, segment eleven; setae or bristles usually distinct, with some of them split or curved or else in groups of more than two; usually, but not always, about one or two inches long; usually, but not always, aquatic —Bristle Worms 43.
Clitellum usually wide and usually beginning on or posterior to segment twelve; setae usually very minute, simple and usually singly or in pairs; rarely with many setae in a ring-like arrangement around the segments; usually getting to be several inches long; usually, but not always, terrestrial—Earthworms 62.

43. With one or two setae per bundle 44.
With more than two setae in some bundles, either dorsally or ventrally (ventral setae may be retractile and difficult to see) 47.

44. Extremely slender, thread-like; with two, long, separate, ventral setae and two, minute, dorsal setae per segment; usually whitish; usually getting to be several inches long; usually terrestrial
Haplotaxis Hoffmstr. (of Family *Haplotaxidae*)
(*Phreoryctes* Hoffmstr.)
Moderately stout; setae usually arranged as pairs of curved spines; usually with a reddish, dorsal blood vessel giving off side branches discernible through the body wall; usually about one or two inches long; usually aquatic—Family *Lumbriculidae* 45.

45. Some of the setae split at the ends
Lumbriculus Grube
Setae or spines simple-pointed 46.

46. With a finger-like proboscis from the front of the head
Sutroa Eisen
No proboscis
Eclipidrilus Eisen

47. Reproducing by fission, often showing a narrowed, clear section through the middle; clitellum, if present, much anterior; usually with bright color spots or else transparent, with the blood showing pale red 48.
Reproducing sexually; with a clitellum (thicker, dull section) in the region of segments ten to twelve in the reproductive season; body usually white or yellowish or else with pulsating hearts and the blood showing bright red 56.

48. With straight bristles only, which are simple-pointed; body usually, but not always, with bright spots of red, yellow or green
Aeolosoma Ehrenberg (of Family *Aeolosomatidae*)
With some of the setae split or curved; body usually transparent, with the blood showing pale red; Family *Naididae* 49.

49. No setae on the dorsal surface
Chaetogaster Baer
With setae on the dorsal surface 50.

50. Posterior end bearing finger-like gill structures 51.
No finger-like gill structures on the posterior end 52.

51. With the two ventral gill structures on the posterior end much longer and slenderer than the others
Aulophorus Schmarda
Gill structures not greatly differing
Dero Oken

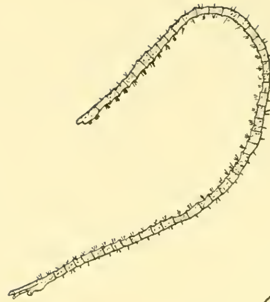
52. With a finger-like proboscis from the anterior end 53.
No proboscis 54.

53. Dorsal setae starting on the second segment
Pristina Ehrenberg
Dorsal setae starting on the fifth or sixth segment
Stylaria Lamarck

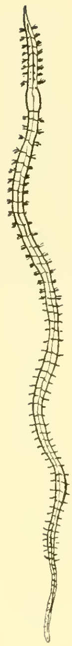
54. Dorsal setae starting on the second segment
Naidium Schmidt
Dorsal setae starting on the fifth or sixth segment 55.

55. With one or more of the setae on the sixth segment much longer than the setae on the other segments
Slavina Vejdovsky
Not so —
Nais Müller

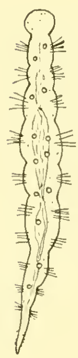
56. Setae simple-pointed; usually white or yellowish; aquatic or terrestrial; Family *Enchytraeidae* 57.
Some of the setae with more than one tip; usually with bright red blood showing; usually living in mud with one end buried in a mud tube



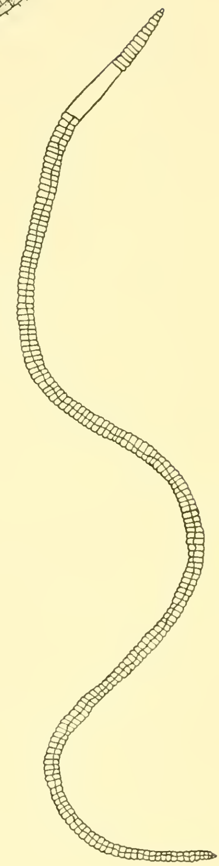
AULOPHORUS
(ENLARGED)



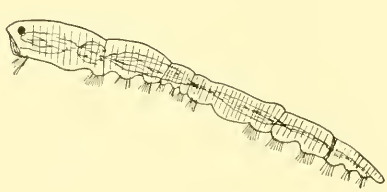
TUBIFEX
(ENLARGED)



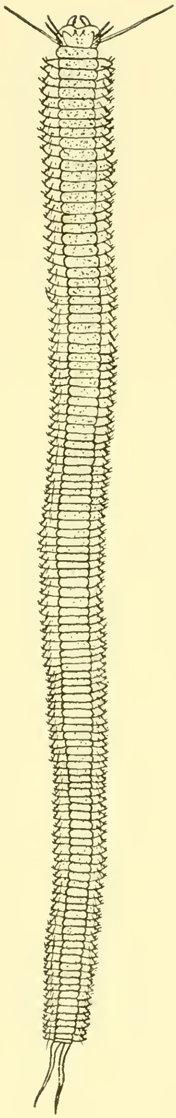
AEOLOSOMA
(ENLARGED)



SPARGANOPHILUS



CHAETOGASTER
(ENLARGED)



NEREIS

and the other end waving in the water above; several common genera identified mainly by the internal anatomy; two common genera are given here; Family *Tubificidae* 61.

57. Oesophagus widening suddenly into the intestine
Henlea Mich.
Oesophagus merging gradually into the intestine 58.

58. Inner setae in setae bundles shorter than the outer setae
Fridericia Mich.
Setae about equal in length 59.

59. Setae straight
Enchytraeus Henle
Setae curved at tips 60.

60. No sperm sacs; with very few bundles of four setae
Lumbricillus Orsted
With sperm sacs; with several bundles of four setae
Mesenchytraeus Eisen

61. None of the dorsal setae simple-pointed
Limnodrilus Claparède
Some of the dorsal setae simple-pointed; some usually split into three or more tips
Tubifex Lamarck

62. With four single setae per segment; clitellum on segments eleven to fourteen; body thread-like; color whitish
Haplotaxis Hoffmstr. (of Family *Haplotaxidae*)
(*Phreoryctes* Hoffmstr.)
With eight or more setae per segment, usually in pairs, rarely in a ring-like arrangement around the segments; clitellum beginning on or posterior to segment twelve and extending to segment seventeen or beyond 63.

63. Clitellum beginning after segment eighteen; male pores on a segment between twelve and fifteen inclusive; Family *Lumbricidae* 64.
Clitellum beginning before segment eighteen; male pores on a segment between seventeen and nineteen inclusive 73.

64. With the prostomium completely dividing the peristomium above; large, thick worms
Lumbricus Linn. em. Eisen Night-crawlers
(Two common species given here) 65.
With the prostomium incompletely dividing the peristomium above; worms smaller and more slender 66.

65. Clitellum on segments 31 or 32 to 37; color purplish
Lumbricus terrestris Linn.
Clitellum on segments 26 or 27 to 32; color pinkish
Lumbricus rubellus Hoffmeister

66. Clitellum beginning on segment thirty
Octolasium Orley em. Rosa
(Representative species, *O. lacteum* Orley)

Clitellum beginning before segment thirty (*Helodrilus* Hoffmeister. This genus has been split into several subgenera, which are now regarded as genera.) Dew Worms 67.

67. Clitellum before or just reaching segment twenty-seven; color of most species brownish
Eiseniella Mich.
(Representative species, *E. tetraedra* (Savigny))
Clitellum reaching behind segment twenty-seven; most species reddish or banded 68.

68. With two pairs of sperm sacs in segments eleven and twelve; no spermathecal pores
Bimastus (or *Bimastos*) Moore
(Representative species, *B. tenuis* (Eisen))
Usually with three or four pairs of sperm sacs in segments nine to twelve; with spermathecal pores 69.

69. Spermathecal pores opening on the back above the upper line of setae
Eisenia Malm em. Mich.
(Two common species given here) 70.
Spermathecal pores opening below the upper line of setae 71.

70. With a dark ring on each segment
Eisenia foetida (Savigny)
Plain reddish
Eisenia rosea (Savigny)

71. With three pairs of sperm sacs; setae placed singly or in wide pairs
Dendrobaena Eisen em. Rosa
(Representative species, *D. subrubicunda* (Eisen))
With four pairs of sperm sacs; setae in close pairs
Allolobophora Eisen
(Two common species given here) 72.

72. Usually with more than 130 segments; reaching six inches
Allolobophora caliginosa (Savigny)
With less than 130 segments; not over three inches long
Allolobophora chlorotica (Savigny)

73. Clitellum on approximately segments 15 to 25
Sparganophilus Benham (of Family *Glossoscolecidae* of some writers, Family *Sparganophilidae* of others)
(Representative species, *S. eiseni* Smith)
Clitellum beginning on segment 12 to 14 and extending not farther than segment 21; Family *Megascolecidae* 74.

74. Setae very numerous, arranged in a ring-like arrangement around the segments (an introduced genus)
Pheretima Kinberg
(Representative species, *P. elongata* (E. Perrier))
Setae in four pairs per segment 75.

75. With two consecutive gizzards 76.
With one or no gizzard 77.

76. Clitellum extending to segment 19 or 20; male pores on segment 17 (an introduced genus)
Dichogaster Beddard
(Representative species, *D. bolaui* (Mich.))
Clitellum extending to segment 18; male pores on segment 19
Diplocardia Garman
(Representative species, *D. communis* Garman)

77. Gizzard vestigial or absent; southern species 78.
With one gizzard; western species 79.

78. Calciferous glands in segment nine or in nine and ten; clitellum on segments 13 to 19 or 20 (Family *Ocnerodrilidae* of some writers)
Ocnerodrilus Eisen
(Representative species, *O. occidentalis* Eisen)
No calciferous glands; clitellum on segments 13 to 16
Microscolex Rosa em. Mich.
(Representative species, *M. phosphoreus* (Duges))

79. (Two genera which are distinguished only by the minute structure of the nephridia or excretory organs); with "meganephridia" or one pair of large nephridia in each segment
Plutellus E. Perrier
(Representative species, *P. marmoratus* (Eisen))
With "micronephridia" or several pairs of small nephridia in each segment
Megascolides McCoy
(Representative species, *M. americanus* Smith)

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MOLLUSKS

Chapter 6

Shells of snails and of clams or mussels have apparently always interested man. Before Columbus arrived, the American Indians used shells or objects made from them as ornaments and as a medium of exchange. Clam valves were in wide use as spoons and scrapers. At the present time the collecting of shells is a wide-spread hobby, and almost all of us who visit the sea-shore gather some of the more attractive specimens.

The collector, fortunately, need not confine his efforts to marine shells, but can find a multitude of varieties both on land and in fresh water. Indeed, before sewage and factory wastes had destroyed the life in many of our rivers, America could justly claim to have more forms of fresh-water mollusks than any other area in the world. The Coosa River in Alabama became world famous among scientists because of the number of species of clams and snails peculiar to it.

The ecological problems connected with the distribution of mollusks have received much and deserve more study. The famous work of J. T. Gulick on the land snails of Hawaii, where each valley was found to have a different variety of tree snail of one genus, *Achatinella,* with a degree of difference proportional to the distance between valleys, has important bearing on our theories of species forming. The distribution of fresh-water clams or mussels is an excellent index of the condition of the streams, since clams cannot travel far from place to place as the circumstances of their environment change, as do fishes and other aquatic animals.

The taxonomist naturally considers the whole animal rather than the shell alone, and the finer points of classification are based on anatomical studies of the soft parts, such as the gills and reproductive organs of clams and snails and the rasp-like tongue or radula of the snails. Although all this study is essential to the establishment of classification, once the taxonomic position has been determined an authority can usually identify the animal by the shell alone. The present keys are an attempt to make it possible for the beginner to identify the specimens he may find from an examination of the more evident structures.

Most snails carry a one-piece shell, spirally coiled around a central axis called the *columella.* A few small fresh-water snails, like some of their marine relatives, have lost the spiral coiling and developed a pyramid-like or cone-like shell. Several land genera have almost or quite dispensed with their shells and are commonly called slugs. Most of these slugs have marks on their backs where the shells might be expected, giving one the impression that they have temporarily laid aside their houses in order to enjoy more ease or less impeded travel.

There are in the United States over twelve hundred species and varieties of land snails and slugs and over fourteen hundred fresh-water snails. Some of these may be found in almost every woodland, pond and stream. Slugs often invade our gardens or damp cellars and leave shining trails of mucus which notify us of their nocturnal wanderings.

For complete identification of a snail the whole animal or a record of its habitat is usually needed. For example, there is no shell character which will satisfactorily separate the land from the fresh-water snails. If the whole animal is at hand, one can check on other characters. Land snails almost always bear their eyes on the ends of the longer tentacles, often miscalled "horns". The eyes of most amphibious and water snails are at the bases of the tentacles. Land snails usually have two pairs of tentacles, while water snails usually have but one pair. Water snails may have either lungs or gills. A snail with gills may have a horny or limy disc, called an *operculum,* attached to the side of the body in such a position that it serves as a door to the shell when the animal is retracted. The presence or absence of an operculum and the details of its markings are useful characters for snail identification.

Another structure examined by experts in snail classification, but not used in general shell identification, is the *radula,* a tongue-like, rasping organ. One who has kept snails in a well established aquarium has probably noticed the peculiar action of this structure and the ripple-like markings it leaves on the glass, where the snail has scraped off the algal growths. Most snails are largely herbivorous but a few, such as the land snail, *Haplotrema,* are carnivorous. Some species may act as scavengers.

Most of the pulmonate snails are hermaphroditic, while the operculate snails are usually unisexual. Some snails, such as *Viviparus,* retain their eggs until development is completed, and each little snail has its protective shell formed when it is born. Many snails, however, lay eggs in gelatinous masses. Some, like *Helisoma,* deposit a flat, rather solid disc of jelly containing about twenty eggs. Others, like *Physa* and *Lymnaea,* leave a rather loose and more or less cylindrical mass of jelly enclosing the eggs. A few snails, like *Paludestrina,* deposit eggs on the outside of their own shells or on the shells of others of their own species. Several of the land snails and slugs deposit their eggs singly under damp logs and boards, each egg with its coating looking like a pinhead of milky jelly. Some snails lay shelled eggs. *Pomacea,* the infusoria snail of the aquarist, deposits a mass of shelled, pinkish eggs on some convenient plant or tree trunk above the surface of the water. One large tropical species of land snail lays an oval egg an inch or so long which looks very much like a turtle or snake egg. Many marine snails have a complicated infancy involving a ciliated, free-swimming stage called a *veliger*. Land and fresh-water snails have a more variable environment with which to contend and have telescoped their developmental stages into a brief period while they are still within the egg or else have omitted the ancestral recapitulations entirely.

Snails are seldom of much direct economic importance to man. In Europe some of the larger snails are used for food. In America their use is indirect, since most of us prefer to eat the fish and birds that feed upon the snails. The diet of a number of the fishes, such as the pumpkinseed sunfish and some of the suckers, consists of twenty-five per cent or more of mollusks. Occasionally land snails, especially slugs, are destructive to tender garden plants. One genus of snails, *Lymnaea,* serves as an intermediate host for the sheep liver fluke, a parasite that frequently causes great losses.

Snail shells are easily preserved. A shell in which the occupant has died and decayed often loses its markings and luster and is regarded as a "dead shell", of little value to collectors. During and after damp warm weather on land, and at almost any time in the water, live snails can be obtained. Logs or boards which have been long submerged, and stems of water plants, usually harbor snails. On land, snails are usually found under loose bark or decaying logs or stumps. Live snails, unless very small, are usually killed by dropping them for a moment or two into boiling water. The animal can then be gently "unscrewed" from its shell with the aid of a pin. If an operculum is present, it should be removed, dried flat between two pieces of glass, and placed inside the shell, the aperture of which is then plugged with cotton-wool. Even if the operculum is lost, the cotton plugs should be used in all operculate shells as an indication. Inoperculate shells are left open. A number should be written on the shell with India ink to correspond to the number of the label or written record, on which the place and date of collection and other useful data are given.

Minute shells may be dropped into alcohol for a day or two and then dried, as the occupants will then mummify and not spoil the shells. Small or delicate shells are usually kept in glass vials, with cotton below and cotton plugs above, or else are put, together with their labels, into gelatin capsules, which are available at druggists. The number and the record of date and locality should always be most carefully recorded, as a collection without such data has lost much of its scientific value.

There are two families of bivalve mollusks found over most of the United States. The members of the larger of these, the *Unionidae,* are the common clams or fresh-water mussels. They have nacreous or mother-of-pearl linings to the shells and usually attain an adult length of more than an inch. The other family, the *Sphaeriidae,* are commonly called "finger-nail shells". They are usually less than an inch long and have dull, instead of iridescent, linings.

Although often ignored by collectors, probably because of their small size and uniform appearance, they constitute an important item in the diet of fishes and other aquatic animals.

North America is extremely rich in varieties and numbers of fresh-water mussels or clams. Many genera have apparently originated in the ideal environment of the Mississippi valley and have since spread widely. The shells of the various species show great variation in size, shape and coloring, and have attracted the interest of amateur and specialist since the settlement of the country.

The living clam is well protected by its shell, and not much of the animal's body is usually visible. As one rows slowly along in shallow water, he may see the undisturbed clam at its normal activities. The shell is usually half buried in mud or gravel. The hinge joint is uppermost and the anterior end tilted downward. Between the slightly separated valves of the shell, behind the horny hinge, extend two tubular projections. The upper one is formed by a smooth, mottled membrane and is called the *exhalent siphon.* Below and behind it is another slightly larger opening, surrounded by a circle of membranous tentacles. This is the *inhalent siphon,* which serves both for conducting aerated water to the gill chamber and for taking in the minute organisms or microscopic plants upon which the animal feeds. The clam usually takes up a position with the siphons headed up stream, so that its food is brought down with the current. The sensitive tentacles of the lower siphon warn the clam to close if anything undesirable touches them. To the naturalist who is used to marine animals the fringed inhalent siphon recalls the sea anemone.

If one picks up the clam quickly, he may see that a large muscular part of the body, called the *foot,* was protruding on the lower side of the animal from between the valves of the shell. Since this foot has somewhat the shape of an axe blade, clams are frequently referred to by zoologists as *Pelecypoda,* meaning hatchet-footed. The foot serves to anchor the animal in a good feeding ground or to enable it to crawl from place to place. As the clam progresses, this foot and the edges of the shell plough a furrow in the soft mud, so that one can easily trace the creature's wanderings. Most clams prefer water from one to three feet deep, and move as conditions change.

Within the shell and hanging down on each side of the body of the clam are the *gills,* two on each side, the inner pair being the longer. Each gill resembles a curtain folded upon itself or a double curtain continuous at the bottom. The gills are crosswise divided into compartments called *water tubes.* Some of the water tubes of the female clam serve as *ovisacs* during the breeding season and may be discolored or distended with developing eggs. The ovisacs make up the portion of the gills known as the *marsupium.* Clam taxonomy is based largely upon the size and structure of the marsupium.

When, for commercial reasons, it seemed desirable to increase the number of clams in our rivers, the experts of the Bureau of Fisheries discovered that they were attempting a most complicated task. Almost all clams must undergo a parasitic stage on the gills, or sometimes on the fins, of some fish. Complicating matters still more, it was found that for each kind of clam there must be a particular kind of fish host. As it was finally worked out, the developmental history makes an interesting story. The female clam carries the fertilized eggs in the modified portion of the gills called the marsupium. When they have reached a certain stage of development, the clam will extrude them at the slightest stimulus, such as the passing of a fish. The larval clams, called *glochidia*, are shot out in immense numbers and some of them are likely to be taken into the mouth of a fish and to find lodgment in its gills. If the fish is of the right species and has not yet acquired immunity by having carried many young clams previously, the glochidia encyst on the gills and complete their larval development. Later they escape from their cysts and, if they are fortunate enough to emerge into a favorable part of the stream, begin their lives as clams.

Much work has been done on glochidia and their hosts, but much more remains to be discovered. Glochidia, as found on the gills of fish, can often be identified to genus and occasionally to species. As the first step, three main types of glochidia, based on their shapes, are recognized: the axe-head type, as in the pink heel-splitter; the hooked, as in the floaters and the white heel-splitter: and the hookless, as in the purple pimple-back. By this method of study the natural fish hosts for a number of our common clams have been discovered. In addition to its scientific value, this information is of value to the fisherman. If he finds shells of the yellow or slough sand shell, he may be sure gars are present; pimple-backs point to catfishes; mucket and blue point indicate bass; and so on. The glochidia of some species may be carried by salamanders, as *Simpsoniconcha ambigua* on the gills of *Necturus maculosus.*

The scientific names of clams have been subjected to much revision during the past twenty years. Since shells are attractive and easily preserved, it is not surprising that practically all our early American naturalists, as well as many European scientists who employed collectors here, named our clams, often working in ignorance of what their contemporaries were doing. Under these conditions most of our clams were described at different times under different names, and the application of the law of priority has often been difficult. The soft parts of the animal were long completely ignored, and even localities of collections were overlooked or unrecorded. One Mississippi valley shell was actually described by a European scientist as coming from Peru and was given the scientific name of *peruviana.*

Recent studies have shown that clam shells may vary greatly with their environment, and indicate that in several cases clams that have been regarded as belonging to two or three different species may be only ecological variations of one species. As a general rule, clams from acid or neutral waters have thinner shells than those of the same species in alkaline or limestone regions. Individuals in small streams and in rapid water are not as wide proportionally as those in large or slowly moving streams. Another variation which has frequently puzzled taxonomists is found in some of the normally knobby or pustulate clams, which in swift headwaters may develop quite smooth shells. The color of the nacre or mother-of-pearl lining also varies decidedly. In some localities all shells of one species may be pink or reddish inside and in other localities white, while sometimes both red and white nacred varieties may occur in the same place. Age and sex may also cause marked differences. Female shells are often more swollen and rounded posteriorly than the males. Old shells are usually duller colored than the young, and may lose the rays altogether. The ratio of length to depth may also vary with the age of the clam.

About 1890 began the first serious attempts to utilize the heavy-shelled varieties of clams from the Mississippi valley for pearl buttons, knife handles and other novelties. By 1910 a twenty million dollar industry had developed, thousands of tons of clams were gathered annually, and button factories sprang up wherever shells were available. Few of these factories were large and, when the local supply was exhausted, they were moved to other localities. Many of them cut, or rather sawed, out the "blanks" or discs, and sent them to other points to be finished. The almost unregulated fishing, the improvement of collecting methods, the digging of drainage ditches and the straightening of streams, and the increased pollution of rivers by sewage and factory wastes quickly led to the almost complete extinction of many of the most useful species of clams and the resultant decline of the industry. Importation of marine shells and the introduction of new synthetic plastics now seem to have rung the knell of the fresh-water, pearl button industry.

An added inducement to clammers was the possibility of finding a valuable pearl, for fresh-water mussels produce pearls hardly inferior to those of tropic seas. An especially fine pink or green pearl might bring enough money to enable the finder to have a never-to-be-forgotten spree. As a matter of fact, the annual crop of pearls from the Mississippi valley is estimated at about $300,000.00 Most of them, however, are irregular in size and are termed slugs, bringing to the finder only a few dollars.

Studies have shown that almost any foreign body, such as a cestode, nematode, or even a grain of sand, may become the nucleus of a pearl. Layers of nacre are deposited over this nucleus by the mantle. Those developing in the soft parts near the beak cavity are usually the most symmetrical and therefore the most valuable. Many centuries ago the Chinese discovered that it was possible to induce pearl formation by inserting some object which might serve as a nucleus. Small images of Buddha were often used, doubtless strengthening the faith of the superstitious pearl divers who later found the pearly images. The Japanese later developed this process commercially. In this country promising experiments in pearl culture have been carried out with the marine abalone snail. Clams carrying pearls of any great size are often deformed, the usual variation being a furrow down one valve and a corresponding elevation on the other. Sometimes the animal rids itself of the pearl, and the cast-out pearl may be found among gravel. Because of the formation in concentric layers a tarnished or discolored pearl can sometimes be restored to commercial value by the removal of some of the outer layers, but this "peeling" is a task for experts.

Clams, like snails, should be gathered alive, if good shell specimens are wanted. When the stream is muddy, it is usually possible to wade into shallow water and feel around for them. If one is especially hardy, wading barefoot is an excellent method of locating clams, but one must take care that he does not get a practical demonstration of the reason why some clams are called "heel-splitters". A rake may occasionally be used to advantage. Commercial clammers use a boat from which hangs a bar bearing several lines, each with a twisted-wire, four-pronged, "crowfoot" hook. As the boat drifts slowly downstream, the crowfoot bar is allowed to slide along the river bed. The hooks enter the gaping posterior parts of the clams, which close tightly upon them. After the boat has drifted for some distance, the bar is pulled up and the clams that are found hanging to the hooks are removed.

Having captured the clam, it may be opened either by dropping it into hot water or by slipping a thin knife blade between the valves, on each side of the hinge, and cutting the adductor muscles. The body of the animal can then be removed and the shell washed. If it is overgrown with algae or encrusted with marl, a brief bath in oxalic acid will usually clean it. After the shell is cleaned, it is advisable to give the epidermis a thin coat of vaseline and to dry the shell slowly in a fairly cool place. Unless these precautions are taken, the shell is likely to crack badly as it dries. The locality and date records may be written with India ink or pencil on the lining of the shell.

Some Pointers For Identification.

If the soft parts of the clam are conspicuously colored, the collector should make note of the fact, as it may aid in identification. For example, the animal of *Quadrula flava* is orange-red, while that of *Quadrula coccinea,* which has a quite similar shell, is white. *Strophitus undulatus, Decurambis marginata* and *Pleurobema cyphyum* also have reddish soft parts, while most clams are white or yellowish. The gills of the female clam may derive color from the eggs carried in the ovisacs. Thus *Quadrula coccinea* and *Quadrula undata* have red eggs, and the marsupium of each of these species therefore appears to be red.

In using the clam key one should remember that the hinge is regarded as the most dorsal region, and that the hinge is posterior to the beak or umbone. The early American conchologists sometimes forgot the latter point, and as a result their descriptions do not always agree with their figures. If the shell is held so that the hinge is on top and level, it will greatly facilitate determining whether the posterior ridge runs to the mid-posterior or to the post-basal point, often a useful character for identification. A quick method of approximating proportions is the stunt of placing the valves together with one valve across and at right angles to the other. This makes it at once apparent whether the shell is twice as long, or less or more than twice as long, as its height. For more exact measurements a ruler should be placed across an open valve, and the straight distance taken for height or length.

Snail shells are right- or left-handed. An easily remembered and quick method of determining the direction of coiling is to hold the shell with its spire up and its aperture toward the observer. If the aperture is on his right, the shell is dextral; if on his left, sinistral. Or, looking down on the spire, clockwise coiling is right or dextral, counter-clockwise is left or sinistral. The whorls are numbered from the center outwards, the apical whorl being the first, but it is usually more convenient to count them in the opposite direction, starting with the body whorl directly opposite the edge of the aperture.

The height of a snail shell is usually considered to be the vertical distance from the apex to the lower edge of the aperture. The width is the greatest diameter at right angles to the axis, although sometimes in heliciform shells the width is considered to be the greatest oblique diameter. The aperture of the shell is usually very important from the taxonomic point of view. The free edge of the aperture is called the *lip*, the outer side being called the *outer lip* and the part curving upwards toward the base of the columella the *inner lip*, and may be thin-edged or reflected. The aperture is often constricted by folds or protuberances called *lamellae* or *denticles*, although for convenience often referred to as "*teeth*", and so called in the key.

The amateur collector may be confused by young *Polygyras*, which may not yet have acquired the reflected lip characteristic of adult specimens. Most species of this group have rather dull, yellowish shells. Most of the species of Family *Zonitidae*, which are often confused with young *Polygyras*, have uniformly shining or semi-shining shells. The keys are necessarily based on average, adult specimens. The snail key is primarily a key to genera only, although a few of the common species of some of the more widely distributed genera are included. State surveys and regional books should be consulted for particular localities.

OUTLINE OF THE CLASSIFICATION OF THE LAND AND FRESH-WATER MOLLUSCA OF THE UNITED STATES

Class GASTROPODA

Mollusks with a more or less distinct head and a broad, flat foot; usually with a spirally wound shell

Subclass PULMONATA

No true operculum; no gills; cavity between body and mantle serving as lung; hermaphroditic

Order BASOMMATOPHORA

Usually aquatic (one family terrestrial); with one pair of contractile tentacles, with a pair of eyes at their bases

Family CARYCHIIDAE (ELLOBIIDAE)

Small terrestrial or amphibious snails; shell usually with elongate, folded, and often toothed aperture

Common genera — *Melampus*
Carychium

Family LYMNAEIDAE

Aquatic; tentacles flattened; shell thin, usually acutely pointed, and with a large and often flaring aperture; lip thin and simple

Common genus — *Lymnaea*

Family PLANORBIDAE

Aquatic; tentacles thread-like or cylindrical; shell usually discoidal, sinistral or apparently dextral

Common genera — *Helisoma*, *Armigera*, *Gyraulus*, *Promenetus*, *Menetus*, *Drepanotrema*, *Planorbula*, *Carinifex*, *Parapholyx*

Family ANCYLIDAE

Small; aquatic; tentacles triangular; shell cap-like, scarcely or not spiral

Common genera — *Ferrissia*, *Lanx*, *Gundlachia*, *Rhodacmea*, *Amphigyra*, *Neoplanorbis*

Family PHYSIDAE

Aquatic; tentacles thread-like; shell sinistral, with large lower whorl

Common genera — *Physa*
Aplexa
Costatella

Order STYLOMMATOPHORA

Terrestrial; usually with two pairs of tentacles, the larger pair invertible and with eyes at the ends, sometimes with the small anterior pair absent

Family HELICIDAE

Introduced European species; medium to large; shell with a fairly low spire, five to seven whorls; aperture with reflected lip: foot not grooved

Common genera — *Helix* *Cepaea*

Family JACOSTIDAE (HELICELLIDAE)

Introduced European species; small; shell with low spire and thin or partly reflected lip; foot not grooved (Not included in the key)

Common genera — *Jacosta* *Monacha*
Hygromia *Cochlicella*

Family HELMINTHOGLYPTIDAE

Moderate to large; shell globose to depressed, usually banded; lip thin or reflected; foot not grooved; southern and western species

Common genera — *Cepolis* *Micrarionta*
Monadenia *Sonorella*
Helminthoglypta *Sonorelix*
Humboldtiana

Family CAMAENIDAE

Moderate sized; shell pyramidal to discoidal; umbilicate; lip usually not reflected or expanded; body whorl plain colored or with two color bands; foot not grooved; southwestern states

Common genera — *Oreohelix* *Ammonitella*
Polygyrella *Glyptostoma*
Megomphix

Family POLYGYRIDAE

Small to large; shell globose to discoidal; usually plain colored, sometimes banded; aperture with reflected lip, often toothed; foot not grooved

Common genera — *Polygyra* *Triodopsis*
Stenotrema *Allogona*
Praticolella *Vespericola*
Mesodon *Ashmunella*
Trilobopsis

Family SAGDIDAE

Small; shell conic to discoidal; plain colored; lip thin; foot not grooved

Common genera — *Lacteoluna* *Thysanophora*
Hojeda *Microphysula*

Family BULIMULIDAE

Moderate to large; shells higher than wide, usually streaked with color; lip thin

Common genera — *Liguus* *Drymaeus*
Bulimulus *Orthalicus*

Family OLEACINIDAE

Shells with high spire, thin lip, narrow aperture

Common genera — *Euglandina* *Varicella*

Family UROCOPTIDAE

Small, many whorled, slender, tapering shells; lip reflected; toothless

Common genera — *Holospira*
Cochlodinella *Microceramus*

Family ACHATINIDAE

Small, slender shells; lip thin; base of columella slightly turned back over umbilical area

Common genera — *Rumina* *Cecilioides*
Lamellaxis *Subulina*

Family CERIONIDAE

Pupa-like; large (about 1″) and solid; often streaked with color; aperture completely reflected

Common genus — *Cerion*

Family TESTACELLIDAE

Animal slug-like, with posterior mantle and rudimentary, ear-shaped shell

Common genus — *Testacella*

Family HAPLOTREMATIDAE

Shells heliciform, moderate sized, thin, semi-shining, with wide umbilicus; foot not grooved

Common genus — *Haplotrema*

Family ZONITIDAE

Shells usually depressed; shining or semi-transparent; aperture large and thin-lipped; foot often grooved

Common genera — *Zonitoides* *Pristiloma*
Mesomphix *Ventridens*
Vitrina *Gastrodonta*
Vitrinizonites *Hawaiia*
Pilsbryna *Retinella*
Clappiella *Euconulus*
Paravitrea *Oxychilus*
Striatura *Guppya*

Family ENDODONTIDAE

Shells with low spire, thin lip; often dull or with color markings; margin of foot grooved, sole ungrooved

Common genera — *Anguispira*, *Discus*, *Helicodiscus*, *Punctum*, *Radiodiscus*

Family SUCCINEIDAE

Very thin shells, with small spire and large body whorl and aperture

Common genera — *Succinea*, *Oxyloma*

Family STROBILOPSIDAE

Minute; parietal wall with several entering lamellae; foot not grooved

Common genus — *Strobilops*

Family PUPILLIDAE

Small or minute; shell almost cylindrical; lip reflected; aperture contracted by teeth or lamellae; with one or two pairs of tentacles

Common genera — *Gastrocopta*, *Pupilla*, *Pupoides*, *Chaenaxis*, *Vertigo*, *Sterkia*, *Pupisoma*, *Columella*

Family VALLONIIDAE

Minute; shells heliciform, with three or four whorls; foot not grooved

Common genera — *Vallonia*, *Planogyra*, *Zoögenetes*

Family CIONELLIDAE (COCHLICOPIDAE)

Small, slender shells, with thin lip and base of columella somewhat twisted; foot not grooved

Common genus — *Cionella*

Family PHILOMYCIDAE

Slugs with no vestige of shell and with mantle covering most of the back; respiratory pore above margin of mantle

Common genera — *Philomycus*, *Pallifera*

Family LIMACIDAE

Slugs; no external shell, but sometimes with a vestige of one in the mantle; mantle exterior; foot smooth

Common genera — *Limax*, *Deroceras*, *Milax*

Family ARIONIDAE

Slugs; sometimes with vestige of shell; mantle anterior; foot with marginal furrows

Common genera — *Binneya* *Arion*
Hemphillia *Prophysaon*
Ariolimax *Anadenulus*
Hesperarion *Zacoleus*

Order SYSTELLOMMATOPHORA

Slug-like; with two pairs of tentacles, the larger pair contractile and with eyes at the ends

Family VERONICELLIDAE

Slugs; mantle covering entire back; respiratory pore below margin of mantle

Common genus — *Veronicella*

Subclass PROSOBRANCHIATA

Shell operculate; with or without gills; usually with one pair of non-contractile tentacles, with a pair of stalked or unstalked eyes at their bases; sexes separate

Order ARCHAEOGASTROPODA

Terrestrial; no gill, mantle cavity serving as lung; operculum with concentric half-rings

Family HELICINIDAE

Shell heliciform

Common genera — *Helicina* *Hendersonia*
Lucidella

Order MESOGASTROPODA

Terrestrial; with or without a small gill; operculum with subspiral markings

Family TRUNCATELLIDAE

With a small gill; spire almost cylindrical; lip continuously reflected

Common genus — *Truncatella*

Family POMATIASIDAE (CYCLOSTOMIDAE)

No gill; shell higher than wide; lip slightly reflected

Common genus — *Chondropoma*

Order SCUTIBRANCHIATA

Aquatic; gill bearing filaments on both sides

Family NERITIDAE

Shell globose, with very short spire; columella area much expanded; eyes on stalks on the outside of the bases of the tentacles

Common genera — *Neritina* *Lepyrium*

Order PECTINIBRANCHIATA

Aquatic; gill usually bearing filaments on one side

Family AMNICOLIDAE

Shell small, usually conical; aperture rounded; with eyes on the outside of the bases of cylindrical tentacles; operculum various, concentric (*Bythinia*) to spiral

Common genera — *Amnicola*, *Bythinia*, *Somatogyrus*, *Fluminicola*, *Pomatiopsis*, *Littoridina*, *Tryonia*, *Paludestrina*, *Lyogyrus*, *Horatia*, *Lyrodes*, *Gillia*, *Cochliopa*, *Clappia*, *Pyrgulopsis*, *Hoyia*

Family VALVATIDAE

Shell small, with low spire; aperture ovate; gill with filaments on both sides (exceptional in this order); with stalked eyes on the inner sides of the bases of cylindrical tentacles; operculum with multispiral markings

Common genus — *Valvata*

Family VIVIPARIDAE

Animal viviparous; with stalked eyes on the outside of the bases of slender tentacles; operculum largely with concentric markings; gill present, no lung

Common genera — *Viviparus*, *Campeloma*, *Lioplax*, *Tulotoma*

Family AMPULLARIIDAE

Aquatic or amphibious; with stalked eyes on the outside of the bases of slender tentacles; operculum with concentric markings; with both gill and respiratory sac

Common genus — *Pomacea*

Family PLEUROCERATIDAE

Shell usually elongate; aperture with slight channel below; eyes on the outside of the bases of the tentacles; operculum subspiral

Common genera — *Pleurocera*, *Io*, *Goniobasis*, *Lithasia*, *Anculosa*, *Gyrotoma*, *Eurycaelon*, *Nitocris*

Class PELECYPODA (or LAMELLIBRANCHIATA)

With two opposing valves joined by a hinge ligament; animal without a distinct head

Order EULAMELLIBRANCHIATA

With gill filaments joined to form continuous lamellae

Family UNIONIDAE

Valves nacreous; siphons short; usually with pseudocardinal teeth and with lateral teeth posterior to them, sometimes absent; with a glochidial larval stage, usually parasitic on fishes

Subfamily MARGARITANINAE

Gills without water tubes and with only scattered interlamellar connections; shell long and usually arcuate; lateral teeth very blurred (Sometimes grouped as a separate family)

Common genera — *Margaritana* *Cumberlandia*

Subfamily ANODONTINAE

Gills crosswise divided into water tubes; water tubes of gravid female lengthwise divided into three sections or tubes, with the middle ones serving as ovisacs to form the marsupium, which extends the length of each outer gill; hinge teeth reduced or absent

Common genera — *Anodonta* *Arcidens*
Strophitus *Arkansia*
Alasmidonta *Lasmigona*
Decurambis *Simpsoniconcha*
Pegias

Subfamily UNIONINAE

Water tubes of gravid female undivided; marsupium sharp-edged, formed from all four gills or from the outer gill on each side; hinge teeth usually complete; interdentum usually flat; valves usually sculptured; no distinction between male and female shells

Common genera — *Elliptio* *Obliquaria*
Pleurobema *Dromus*
Canthyria *Cyprogenia*
Quadrula *Hemistena*
Amblema *Ptychobranchus*
Gonidea

Subfamily LAMPSILINAE

Water tubes of gravid female undivided; marsupium swollen beyond the edge of the gills, usually formed only from the posterior part of the outer gills; hinge teeth usually complete; interdentum usually rounded; valves usually smooth; female shells often more swollen or sometimes more rugose posteriorly than the male

Common genera — *Lampsilis*, *Obovaria*, *Proptera*, *Glebula*, *Carunculina*, *Medionidus*, *Truncilla*, *Lemiox*, *Plagiola*, *Dysnomia*

Family DREISSENSIIDAE

Small; no nacre; beaks terminal; valves narrow and unequal; with conspicuous siphons; foot with byssus (thread or threads used for attachment to rocks, etc.); Atlantic coast (Not included in the key)

Common genus — *Congeria*

Family CYRENIDAE

Small; shell porcelain-like; with hinge plate; with cardinal teeth and anterior and posterior lateral teeth; with two distinct siphons; southern Atlantic and Gulf coasts (Not included in the key)

Common genus — *Polymesoda* (*Cyrena*)

Family SPHAERIIDAE

Small; no nacre; no hinge plate; with cardinal teeth and anterior and posterior lateral teeth; generally distributed (Sometimes grouped with the preceding family)

Common genera — *Sphaerium*, *Musculium*, *Pisidium*, *Eupera* (Tropical species, not included in the key)

Family CYRENELLIDAE

Small; no nacre; with cardinal teeth but no lateral teeth; with two long siphons, contractile, completely united; Florida (Not included in the key)

Common genus — *Cyrenella*

Family RANGIIDAE

Large; no nacre; with cardinal teeth and anterior and posterior lateral teeth; with two short siphons, united below; in brackish waters of the Gulf States (Not in key)

Common genus — *Rangia*

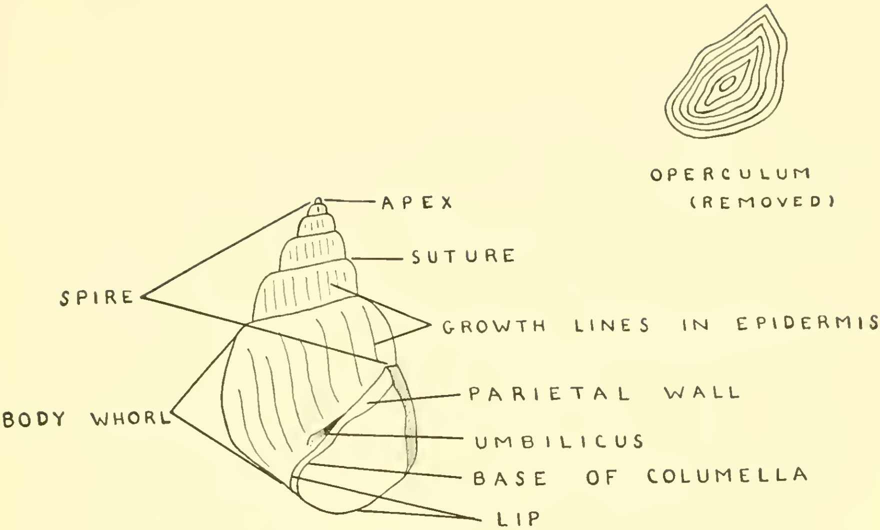


DIAGRAM OF A SNAIL SHELL

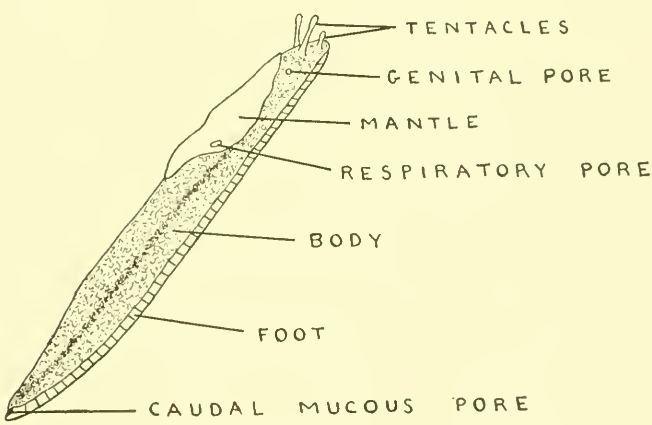


DIAGRAM OF A SLUG

KEY TO THE CLASSES OF LAND AND FRESH-WATER MOLLUSKS

1. Without a shell or with a cap-like or spirally wound, one-piece shell; usually with a head bearing eyes and tentacles and with a broad, flat foot; aquatic or terrestrial
   Class *Gastropoda* Snails and Slugs
   With a bivalve shell; no head bearing eyes and tentacles; foot usually keel-like; aquatic
   Class *Pelecypoda* Clams and Clam-like Mollusks

KEY TO SOME REPRESENTATIVE SPECIES OF THE COMMON GENERA OF SNAILS AND SLUGS

1. Water animals; with only one pair of tentacles; never with eyes at the ends of the tentacles — 2.
   Land animals; with one or two pairs of tentacles — 93.
2. Shell cap-like, not coiled—Limpets — 3.
   Shell more or less coiled — 9.
3. Apex pink; about 1/4″
   Rhodacmea filosa (Conrad)
   Shell almost uniformly brownish — 4.
4. Apex about central; about 3/4″; western states — 5.
   Apex more posterior; shell smaller — 6.
5. Shell fairly solid and about as high as wide
   Lanx patelloides (Lea)
   Shell thinner and more depressed
   Lanx (Walkerola) klamathensis Hannibal
6. Apex cut off internally from the rest of the shell by a septum, appearing externally like a small shell-cap — 7.
   Apex not so separated — 8.
7. Apex with radial striations
   Gundlachia meekiana Stimpson
   (*Kincaidella meekiana* (Stimpson))
   Apex smooth
   Gundlachia hjalmarsoni Pfeiffer
8. Apex smooth
   Ferrissia diaphana (Haldeman)
   (*Laevapex fusca* (Adams))
   Apex with radial striations
   Ferrissia rivularis (Say)
   (*Ancylus rivularis* Say)
9. Shell subconic, scarcely coiled; with a thin columellar plate projecting across part of the aperture; Alabama
   Amphigyra alabamensis Pilsbry Boat Shell
   Shell with two or more coils; no columellar plate across the aperture — 10.

10. Without an operculum (a horny or limy structure attached to the body and used to close the aperture of the shell) 11.
With an operculum 45.

11. Shell minute, with two whorls, wider than high; base of columella broadly expanded; Alabama
Neoplanorbis tantillus Pilsbry
With three or more whorls 12.

12. Shell left-handed (coiled counter-clockwise) or else disc-shaped, coiled almost or entirely in one plane 13.
Shell normally right-handed (coiled clockwise), globular to high 32.

13. Shell left-handed or apparently right-handed, usually coiled in one plane, but occasionally with only the small upper whorls so coiled—Ramshorn Snails 14.
Shell left-handed; spire acute — Tadpole Snails 26.

14. With small teeth back within the aperture; seldom over 1/4″ wide; widely distributed 15.
Aperture not toothed; size various 16.

15. Lip thin
Planorbula armigera (Say) Toothed Ramshorn
(*Segmentina armigera* (Say))
Lip with a thickened crest within
Planorbula crassilabris (Walker)
(*Segmentina crassilabris* Walker)

16. Shell left-handed 17.
Shell apparently right-handed 19.

17. With only the small upper whorls coiled in one plane, so that the shell is Physa-shaped; Florida
Helisoma scalare (Jay)
Shell disc-shaped; west to the Rockies 18.

18. Lip slightly flaring; whorls four and one-half or more, and rather loose; smaller whorls distinct
Helisoma campanulatum (Say) Bell-mouth Ramshorn
(*Planorbis campanulatus* Say)
Aperture not flared; coils tight and four and one-half or less; smaller whorls blending
Helisoma trivolvis (Say) Common Ramshorn
(*Planorbis trivolvis* Say)

19. Aperture flaring; lip thickened; whorls keeled on both sides, with the periphery curved or flat; widely distributed
Helisoma anceps (Menke) Keeled Ramshorn
(*Planorbis antrosus* Conrad)
(*Planorbis bicarinatus* Say)
Lip simple 20.

20. Shell flat below, with the base of the aperture in the same plane as the base of the shell; southern states, Florida to Texas
Drepanotrema cultratum (Orb)
Shell more or less flattened below, with the base of the aperture below the base of the shell 21.

FERRISSIA DIAPHANA

PALUDESTRINA NICKLINIANA

AMNICOLA LIMOSA

AND ENLARGED VIEWS OF OPERCULA

SOMATOGYRUS DEPRESSUS

PHYSA ANCILLARIA

APLEXA HYPNORUM

HELISOMA ANCEPS

PLANORBULA ARMIGERA

MELAMPUS LINEATUS

CARINIFEX NEWBERRYI

LYMNAEA PALUSTRIS

LYMNAEA COLUMELLA

21. Shell much flattened, with the body whorl distinctly keeled 22.
Shell not so much flattened; body whorl sometimes shouldered 23.

22. Body whorl almost concealing the other whorls, when viewed from below; Pacific states
Menetus opercularis (Gould)
(*Planorbis opercularis* Gould)
Whorls visible from both sides; widely distributed
Promenetus exacuous (Say)

23. Body whorl shouldered or faintly keeled above; umbilicus small and deep, with the body whorl almost concealing the other whorls; eastern and central states
Menetus dilatatus (Gould)
Body whorl more symmetrically rounded; umbilicus wide, with most of the whorls plainly visible; generally distributed 24.

24. Shell with cross striations
Armigera crista (Linn.)
(*Planorbis cristus* (Linn.))
Shell finely striate or smooth 25.

25. Epidermis erect between the growth lines; aperture oblique
Gyraulus hirsutus (Gould)
(*Planorbis hirsutus* Gould)
Surface smooth; aperture more even
Gyraulus (Torquis) parvus (Say)
(*Planorbis parvus* Say)

26. Shell narrow; width less than one-half length
Aplexa hypnorum (Linn.)
Shell wider 27.

27. Shell lengthwise ribbed
Costatella costata (Newcomb)
Shell without lengthwise markings except growth lines 28.

28. Whorls blending, so that the sutures appear as scarcely more than fine lines; spire usually so low that it scarcely disturbs the outline of the body whorl; body whorl usually distinctly shouldered; shell usually with fine spiral lines; Maine to Minn. and south to the Ohio River; a river species
Physa ancillaria Say
Sutures evident; spire usually somewhat acute; body whorl less shouldered; shell with or without fine spiral lines 29.

29. With a thick white callus on the parietal wall and around the edge of the lip; seldom over ½″ high; Great Lakes area to the Gulf
Physa integra (Haldeman)
Callus around lip purplish or less conspicuous 30.

30. Shell smooth and shining; seldom much over ½″ high; New England; rarer west of the Alleghenies; not south of the Ohio and Potomac rivers; small stream form
Physa heterostropha (Say)
Shell with fine spiral lines; becoming larger 31.

31. Usually with a trace of an umbilicus, almost covered by the reflected lip; shell solid; lip joins body at an acute angle, making a loop-shaped or shouldered aperture; from Alabama to Texas northward, in stagnant pools

Physa gyrina Say

No umbilicus; shell thin; body whorl rounded; N. Y. to Nebraska and southward to the Ohio River; a lake species

Physa sayii (Tappan)

32. Aperture toothed or ridged; brackish water species

Melampus lineatus Say Ear Shell

Aperture without teeth or ridges; fresh water species 33.

33. Shell globular, usually about as wide as high; tentacles cylindrical; western species 34.

Shell higher than wide; tentacles flattened; generally distributed; *Lymnaea* (*Fossaria*) sp. — Common Pond Snails 35.

34. With a deep umbilicus; shell often keeled around top of whorls

Carinifex newberryi (Lea) Terraced Pond Snail

Scarcely or not perforated

Parapholyx effusa (Lea) California Pond Snail

(*Pompholyx effusa* Lea)

35. Body whorl large and inflated; aperture large and oval or rounded 36.

Body whorl compressed or narrow; aperture moderate to narrow 40.

36. Spire long and slender, usually longer than the aperture

Lymnaea (*Lymnaea*) *stagnalis* (Linn.)

Spire rather thick and usually equal to or shorter than the aperture 37.

37. Spire much shorter than the aperture 38.

Spire only a little, if any, shorter than the aperture 39.

38. Aperture much inflated, larger than the shell; a European species introduced into the eastern states

Lymnaea (*Radix*) *auricularia* (Linn.)

Body whorl and aperture lengthened; native species

Lymnaea (*Lymnaea*) *columella* Say

(*Pseudosuccinea columella* (Say))

39. Columellar area of aperture very broad; over 1″ high

Lymnaea (*Bulimnea*) *megasoma* Say

Columellar area of aperture narrower; smaller

Lymnaea (*Stagnicola*) *emarginata* Say

40. Shell very long and narrow; upper whorls as high as, or higher than, wide 41.

Shell narrow, but with the upper whorls wider than high 42.

41. Aperture extremely narrow, with a continuous lip; shell unlined

Lymnaea (*Acella*) *haldemani* Desh.

(*Lymnaea gracilis* Jay)

Aperture oval; lip not continuous; shell with growth lines

Lymnaea (*Stagnicola*) *reflexa* Say

42. Columella folded or twisted; surface of shell with a malleated appearance; about 1″
Lymnaea (*Stagnicola*) *palustris* (Müller) Hammered Pond Snail
Columella smooth; shell with lengthwise growth lines and often with fine spiral lines; about ½″ 43.

43. Inner edge of aperture slightly curved over the umbilical area
Lymnaea (*Galba*) *humilis* Say
(Includes *Lymnaea modicella* Say)
Inner edge of aperture turned in a more or less triangular expansion over the umbilical area 44.

44. Shell solid; epidermis standing erect on the spiral lines
Lymnaea (*Galba*) *caperata* Say
Shell thin; spiral lines impressed
Lymnaea (*Galba*) *obrussa* Say

45. Inner edge of operculum with small projections which fit into depressions in the base of the columella; fresh and brackish waters of the Florida and Gulf coasts
Neritina reclivata (Say) Wavy-lined Shell
Columellar area of aperture not serrate 46.

46. Shell cup- or turban-shaped, with three whorls, very thin and transparent; inner side of aperture very broad; Alabama
Lepyrium showalteri (Lea) Turban Shell
Not so 47.

47. Aperture circular; operculum circular, with multispiral (tightly wound) markings; body whorl slightly disjoined; usually less than ¼″ 48.
Aperture approaching oval; opercular markings concentric or slightly spiral; body whorl not disjoined 52.

48. Shell much higher than wide; Atlantic states
Lyogyrus pupoideus (Gould)
Shell about as wide as, or wider than, high 49.

49. Whorls rounded 50.
Whorls keeled 51.

50. Operculum with about ten spirals
Valvata sincera Say Smooth Valve Shell
Operculum with about four spirals
Horatia micra (P. & F.)

51. Apex somewhat elevated
Valvata tricarinata (Say) Three-keeled Valve Shell
Apex low
Valvata bicarinata Lea Two-keeled Valve Shell

52. Opercular markings concentric (outer markings concentric, central markings spiral, in one species) 53.
Opercular markings spiral 64.

53. Inner margin of operculum reflected, making the opercular markings concentric half rings; shell heavy and usually with tubercles; Alabama
Tulotoma magnifica (Conrad) Knobby Shell

Operculum oval; outer opercular markings concentric rings; shell not tuberculate 54.

54. With the outer opercular markings concentric, the central ones spiral; whorls usually faintly keeled; about 1/2″; Ohio southwards

Lioplax subcarinata (Say) Keeled Mud Snail

Opercular markings concentric; whorls usually smooth 55.

55. Spire very much shorter than the aperture; shell with revolving bands of color; about 2″; Georgia and Florida

Pomacea paludosa (Say) Infusoria Snail

(*Ampullaria depressa* Say)

Spire about as high as the aperture; color banded or plain; smaller; eastern and central states 56.

56. Operculum limy; color greenish-yellow; about 1/2″

Bythinia tentaculata (Linn.)

(*Bulimus tentaculatus* (Linn.))

Operculum horny; getting to be larger 57.

57. Upper part of aperture forming an angle of about seventy degrees; shell usually dark or with revolving bands of color — Dark or Banded Mud Snails 58.

Upper part of aperture forming an angle of about fifty degrees; shell usually plain greenish — Green Mud Snails 60.

58. Spire slightly shorter than the aperture; umbilicus present, except in southern forms; Mississippi drainage

Viviparus intertextus (Say) Brown Mud Snail

Spire usually longer than the aperture; umbilicus absent or a very narrow chink 59.

59. With four dark bands; N. Y. to Michigan

Viviparus contectoides Binney Banded Mud Snail

(*Paludina vivipara* (Say))

Without bands; Mississippi drainage

Viviparus subpurpureus (Say) Purple Mud Snail

60. Shell rather thin; upper whorls usually eroded; northeastern and north-central states

Campeloma decisum (Say)

Shell solid to heavy 61.

61. Whorls usually rounded; aperture usually about as long as the spire; apical whorl sunk within the second whorl 62.

Whorls usually somewhat flattened; aperture often shorter than the spire; apical whorl raised above the second whorl 63.

62. Shell usually reddish beneath the epidermis; east-central and central states

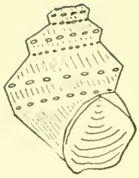
Campeloma rufum (Haldeman)

Shell white beneath the epidermis; shell very thick and heavy; N. Y. to Texas

Campeloma ponderosum (Say)

63. With six whorls; upper Mississippi River

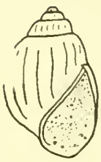
Campeloma integrum (Say)



VALVATA TRICARINATA

VIVIPARUS CONTECTOIDES

TULOTOMA MAGNIFICA



GYROTOMA AMPLUM

NERITINA RECLIVATA

CAMPELOMA PONDEROSUM

LITHASIA ARMIGERA

EURYCAELON ANTHONYI

IO FLUVIALIS

GONIOBASIS VIRGINICA

ANCULOSA PRAEROSA

PLEUROCERA ACUTA

With seven whorls; body whorl more flattened than in the preceding species; Ohio River area

Campeloma subsolidum (Anthony)
(*Campeloma crassulum* Raf.)

64. Lower edge of aperture more or less narrowed or slightly drawn out to a blunt point, in most species; shell often dark-banded within; usually heavy and getting to be over one-half an inch high; several genera and many species, most of them south of the Ohio River, but some farther north and west, and a few species of the genus *Goniobasis* on the west coast; a large and variable group, with genera and species intergrading; Family *Pleuroceridae* 65.
Aperture broadly rounded below; shell usually plain colored; usually solid to thin and less than one-half an inch high 76.

65. With a gap in the upper rim of the aperture along the suture; found in the Coosa River, Alabama

Gyrotoma amplum Anthony Cut-lip Shell
(*Schizostoma ampla* (Anthony))

Aperture complete above 66.

66. Lower edge of aperture produced into a long, narrow half-tube; shell often spinous or tuberculate

Io fluvialis (Say) Spindle Shell
(Includes *Io spinosus* Lea)

Aperture not so much drawn out; shell smooth or rough 67.

67. Columellar area of aperture heavily calloused; aperture slightly longer than the spire in most species 68.
Columellar area slightly thickened; spire somewhat longer than the aperture in most species — Steeple Shells 74.

68. Aperture drawn out but scarcely narrowed below; body whorl smooth to ridged or faintly tuberculate 69.
Aperture narrowed below; body whorl smooth to tuberculate 70.

69. Many species of the genus *Anculosa*. A few species have been referred to the genus *Nitocris* on the basis of difference in number and arrangement of teeth of the radula. Shells vary greatly in sculpture according to locality. Two representative species are given.

Anculosa praerosa (Say)
and
Nitocris carinata (Brug.)

70. Columellar extremity of lip turned sharply inward below 71.
Columellar extremity of lip slightly incurved below 72.

71. Inner edge of lip folded back over a deep umbilical area

Eurycaelon anthonyi (Budd)

With a callus over the umbilical area

Eurycaelon crassa (Haldeman)

72. Aperture well produced below; body whorl usually with a central row of tubercles

Lithasia armigera (Say)
(*Angitrema armigera* (Say))

Aperture not so much produced below; body whorl practically smooth or with a row of tubercles above the middle 73.

73\. Body whorl practically smooth
Lithasia obovata (Say)
Usually with a row of tubercles around the upper part of the body whorl
Lithasia geniculata Haldeman

74\. Columellar area of aperture smooth (Very many intergrading species, of which one representative is given here)
Goniobasis virginica (Gmelin)
Columellar area of aperture folded or twisted (Many intergrading species, of which two representatives are given here) 75.

75\. Body whorl considerably lengthened; sides of body whorl usually almost parallel; outer lip almost perpendicular; operculum small and transparent, with the spiral lines touching the margin at the base
Pleurocera (Strephobasis) curtum (Haldeman)
Sides of body whorl usually diverging; outer lip more oblique; operculum more solid, with the spiral lines touching the margin at the left side
Pleurocera acuta Raf.

76\. Shell rather solid; spire usually slightly shorter than the aperture; columellar area of aperture thickened 77.
Shell usually thinner; spire usually slightly to decidedly longer than the aperture; columellar area thin 82.

77\. Shell wider than high; umbilicus wide; southwestern states
Cochliopa riograndensis P. & F.
Shell slightly higher than wide 78.

78\. Umbilicus oval and deep; Alabama
Clappia clappi Walker Clapp's Shell
Umbilicus narrow or absent 79.

79\. Edge of aperture continuously in one plane; sutures slightly impressed; southeastern states
Gillia altilis (Lea) Gilly
Lip projecting forward; sutures well impressed 80.

80\. Lip projecting centrally; shell solid; West Coast
Fluminicola nuttalliana (Lea) Flood Shell
Lip projecting above; shell slightly thinner; central and southern states — Globe Shells 81.

81\. With a narrow umbilicus; getting to be over 1/4″
Somatogyrus subglobosus (Say)
(*Birgella subglobosa* (Say))
Shell scarcely or not perforated; less than 1/4″
Somatogyrus depressus (Tryon)

82\. Shell lengthwise ribbed; western states
Tryonia clathrata Stimpson
Not so 83.

83\. Whorls keeled or angulated above; west and south 84.
Whorls more rounded; more generally distributed 86.

84. Whorls with a sharp central keel; western states
Pyrgulopsis nevadensis (Stearns)
Whorls angulated above; southern states 85.

85. Shell rather slender; no umbilicus; often with spines along the shouldered area of the whorls
Lyrodes coronatus (Pfeiffer)
(*Potamopyrgus coronatus* (Pfeiffer))
Shell stouter; with a narrow umbilicus; whorls smoothly shouldered
Littoridina monroensis (Frauenfeld)

86. Usually with a small umbilicus; part of operculum with fine, screen-like markings 87.
Shell scarcely or not perforate; no fine, criss-cross lines on the operculum 91.

87. Animal amphibious, found on pond edges; shell about two times as high as wide, with somewhat turreted whorls; foot with a transverse groove anteriorly
Pomatiopsis lapidaria (Say) Amphibious Snail
Animal aquatic; shell globose to narrow, with convex whorls; foot entire — Lake Shells 88.

88. Apex flattened, the second whorl surrounding the tiny nuclear whorl in the same plane 89.
Apex acute 90.

89. With the first three whorls coiled in one plane
Amnicola emarginata (Küster)
(*Cincinnatia emarginata* (Küster))
With the first two whorls coiled in one plane
Amnicola limosa (Say)

90. Spire only slightly longer than the aperture
Amnicola integer (Say)
(*Cincinnatia cincinnatiensis* (Anthony))
Spire decidedly longer than the aperture
Amnicola lustrica Pilsbry

91. Lip not continuous
Hoyia sheldoni (Pilsbry)
Lip continuous — Watercress Snails 92.

92. Aperture broadly oval, scarcely narrowed above
Paludestrina nickliniana (Lea)
(*Bythinella nickliniana* (Lea))
(*Stimpsonia nickliniana* (Lea))
Aperture angled above
Paludestrina longinqua (Gould)

93. Shell absent or very small in proportion to the body of the animal, and scarcely or not coiled — Slugs and Slug-like Mollusks 94.
Shell of two or more coils, almost or entirely enclosing the retracted animal — Land Snails 118.

94. Shell somewhat exposed 95.
Shell hidden or absent 98.

95. Shell slightly spiral 96.
Shell a flattened or convex plate; northwestern states — Plated Slugs 97.

96. Mantle on the rear of the animal, covered by a tiny shell; an introduced species often found in greenhouses
Testacella haliotoidea Draparnaud
(*Testacella europaea* de Roissy)
Mantle more central, partly covered by a small shell; on islands off the coast of California
Binneya notabilis Cooper

97. Mantle covered with papillae; posterior part of body with a median ridge ending in a curved-down projection
Hemphillia glandulosa B. & B.
Mantle slightly wrinkled; posterior half of body somewhat keeled, but without any terminal projection
Hemphillia camelus P. & V.

98. Mantle covering almost or all of the back 99.
Mantle anterior in position 101.

99. Respiratory pore on the right side, posterior, and below the margin of the mantle; Florida
Veronicella floridana (Leidy)
Respiratory pore on the right side, anterior, and slightly above the margin of the mantle; in the eastern and central states 100.

100. Mantle covering the entire back; animal yellowish, with dark blotches which may form three indefinite lengthwise rows; about 3″ or 4″ long; west to Iowa and Texas
Philomycus carolinianus (Bosc)
(*Tebennophorus carolinensis* (Bosc))
Mantle covering all but a small head region; animal grayish, sometimes with a broken dark band down the center of the back; about ¾″ long; northeastern and north-central states
Pallifera dorsalis (Binney)
(*Tebennophorus dorsalis* (Binney))

101. Respiratory pore on the right side and placed centrally or anterior to the middle of the mantle 102.
Respiratory pore placed posterior to the middle of the right side of the mantle 109.

102. Skin coarsely wrinkled lengthwise and often with lengthwise tubercles; genital pore below the respiratory pore; introduced European species 103.
Skin with a network enclosing diamond-shaped patches or with more oblique wrinkles on the sides; genital pore below or behind the right tentacle; western species 105.

103. Back uniformly colored; 2½″ long
Arion ater (Linn.)
Back usually striped; smaller 104.

104. Dark stripe on right side of mantle passing through the respiratory pore
Arion hortensis Fer. Gray European Slug
(*Arion fuscus* (Müller))

Dark stripe on right side of mantle passing above the respiratory pore
Arion circumscriptus Johnston

105. Sole with two lengthwise grooves; tail normal; Cal.
Anadenulus cockerelli (Hemp.)
Sole plain; with a narrowed area around the body about two-thirds of the way back, which may be self-amputated, in most species; Pacific states into Idaho 106.

106. Sides with oblique lines only; no light or dark mid-dorsal stripe
Prophysaon coeruleum Cockerell
Sides with cross lines between the oblique lines; usually with a light or dark mid-dorsal stripe 107.

107. With a dark mid-dorsal stripe
Prophysaon vanattae Pilsbry
Usually with a light mid-dorsal stripe 108.

108. Respiratory pore about central in mantle; about $2\frac{1}{2}''$ long
Prophysaon andersoni (Cooper)
Respiratory pore slightly anterior in mantle; getting to be 3 to 4 inches long
Prophysaon foliolatum (Gould)

109. With a caudal mucous pore; sole indistinctly in three lengthwise sections; western species 110.
No caudal mucous pore; sole distinctly grooved in three lengthwise sections 112.

110. Caudal pore deep and open; less than 2″ long; Cal.
Hesperarion hemphilli (Binney)
Caudal pore filled with spongy tissue; larger 111.

111. Mantle free for about one-fourth of the way back from the front margin; yellowish or brownish, with dark dashes; Cal.
Ariolimax californicus Cooper California Garden Slug
Mantle free for about one-third of its length; yellowish or greenish, with dark dashes or blotches; Pacific states
Ariolimax columbianus (Gould) Columbian Garden Slug

112. Back with two or three unbroken dark stripes; about two inches long; a European species found in greenhouses and introduced into California
Limax marginatus Müller Striped European Slug
Stripes on back usually broken or absent 113.

113. Sides with lengthwise stripes or rows of blotches; large animals, getting to be 5″ or 6″ long 114.
Small (about 1″ to 2″ long), plain colored or irregularly spotted slugs **115.**

114. Color brownish, with gray blotches; a European species found in greenhouses and widely distributed throughout the U. S.
Limax flavus Linn. Spotted Slug
Color brownish, with black blotches; a European species established in various parts of the U. S.
Limax maximus Linn. Giant Spotted Slug

DEROCERAS RETICULATUM

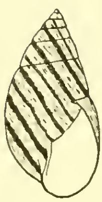
SUCCINEA OVALIS

CIONELLA LUBRICA

COCHLODINELLA POEYANA

CERION INCANUM

LIGUUS FASCIATUS



LIMAX FLAVUS

BULIMULUS ALTERNATUS

PHILOMYCUS CAROLINIANUS

EUGLANDINA ROSEA

115. Back smooth between conspicuous lengthwise furrows; mantle with a U-shaped groove; an introduced species often found in greenhouses
Milax gagates Drap. Greenhouse Slug
(*Amalia gagates* (Drap.))
Back with fine transverse striae; no U-shaped groove in the mantle 116.

116. Back keeled behind mantle; mantle granular; western states
Zacoleus idahoensis Pilsbry Idaho Slug
Back keeled only toward tail; mantle with concentric lines; generally distributed — Gray Garden Slugs 117.

117. Color grayish or brownish; with flat tubercles over the surface, with dark lines or furrows separating them; about 1″ to 2″ long
Deroceras reticulatum (Müller)
(*Agriolimax agrestis* (Linn.))
Color yellowish to dark; with rounded tubercles over the surface, of the same color as the separating furrows; about 1″ long
Deroceras laeve (Müller)
(*Deroceras gracile* Raf.)
(*Agriolimax campestris* (Binney))

118. With an operculum (a permanent structure attached to the body and used to close the aperture of the shell); lip more or less reflected; with one pair of tentacles with stalked or unstalked eyes at their bases 119.
Without an operculum (Species of *Helix* and related genera may have an epiphragm — a temporary seal for the opening, while the snail is in a resting condition. This epiphragm is a dried and hardened secretion that is not attached to the body.); usually with two pairs of tentacles, with eyes at the ends of the larger pair, sometimes with the small, anterior pair absent (except *Carychium exiguum,* which has one pair of tentacles, with a pair of eyes at their bases) 124.

119. Shell narrow, much higher than wide 120.
Shell heliciform, little, if any, higher than wide; less than ½″; southern states 121.

120. Shell lengthwise ribbed; lip continuously thickened and reflected
Truncatella bilabiata Pfeiffer
Shell with fine lengthwise and spiral lines; lip slightly reflected
Chondropoma dentatum (Say)

121. Shell with lengthwise striations 122.
Shell smooth 123.

122. Spire scarcely elevated above the body whorl; less than ⅛″ wide; Florida
Lucidella tantilla (Pilsbry)
Height about equal to width; about ¼″; north-central states to N. C.
Hendersonia occulta (Say)

123. Shell slightly wider than high; slightly under ¼″; southeastern and south-central states
Helicina orbiculata (Say)
Shell slightly higher than wide; slightly over ¼″; Texas
Helicina chrysocheila Binney

124. Shell distinctly higher than wide 125.
Height about equal to, or less than, width 153.

125. Aperture toothed or with the outer side of margin reflected 126.
Aperture toothless; lip thin 136.

126. Aperture round and toothless; edge of aperture completely reflected all around; about ½″ high 127.
Edge of aperture incomplete across the parietal wall 128.

127. Body whorl curved, disjoined; aperture almost circular; southeastern states
Cochlodinella poeyana (Orb.)
(*Urocoptis poeyana* (Orb.))
(*Cylindrella poeyana* (Orb.))
Body whorl keeled below and scarcely or not disjoined; aperture somewhat squarish; southwestern states
Holospira roemeri (Pfeiffer)
(*Cylindrella roemeri* Pfeiffer)

128. Shell narrow, tapering; with more than seven whorls; aperture toothless; about ½″ to ¾″; southern states
Microceramus pontificus (Gould)
(*Macroceramus pontificus* (Gould))
Shell more cylindrical, approaching capsule-shaped; whorls may or may not exceed seven; toothed or toothless 129.

129. Shell very thin and transparent, minute; aperture with about two teeth; with one pair of tentacles, with eyes at their bases; generally distributed
Carychium exiguum (Say)
Shell translucent or opaque, usually rather solid; large or small; toothed or toothless; with one or two pairs of tentacles, with eyes at the ends of the single or larger pair 130.

130. Shell white or streaked with color; about 1″ high; Florida
Cerion incanum (Binney) Giant Pupa Shell
Usually plain brownish colored; usually much smaller; more generally distributed; Family *Pupillidae* — Pupa Shells 131.

131. Shell widely umbilicate, with a hollow axis to apex; Arizona
Chaenaxis tuba (P. & F.)
Not so; more generally distributed 132.

132. With only one pair of tentacles 133.
With two pairs of tentacles, the lower pair minute 134.

133. Tooth or lamella on parietal wall nearest outer edge of aperture not reaching to junction of lip with parietal wall
Vertigo ovata Say
Tooth or lamella on parietal wall nearest outer edge of aperture reaching to junction of lip with parietal wall
Sterkia hemphilli (Sterki)

134. Usually with five or more teeth in the aperture; teeth on parietal wall usually joined together
Gastrocopta armifera (Say)
(*Bifidaria armifera* (Say))
Usually toothless or with one small tooth 135.

135. Spire somewhat tapering; coils rather loose
Pupoides albilabris (Adams)
(*Pupoides marginatus* (Say))
Spire more cylindrical; with close coils
Pupilla muscorum (Linn.)

136. Shell of three or four whorls 137.
Shell of five or more whorls 141.

137. Shell almost globular; shell minute 207.
Body whorl and aperture very large and flaring; smooth, thin shells, about ½″ high, usually found near pond edges; generally distributed — Amber Snails 138.

138. Aperture about one-half the length of the shell
Succinea avara Say
Aperture longer 139.

139. Shell rather dull and opaque
Succinea campestris Say
Shell more translucent, shining 140.

140. Inner side of aperture (parietal wall) almost vertical
Oxyloma retusa (Lea)
Inner side of aperture more oblique
Succinea ovalis Say

141. Inner side of aperture (columellar extremity) truncate or slightly rolled inwards 142.
Lower inner margin of aperture slightly turned outwards 143.

142. With about ten whorls; shell over three times as high as wide; ½″ to ¾″ long; introduced into Florida
Subulina octona (Brug.)
With less than ten whorls; shell wider in proportion to height; about 1½″ high; southern states
Euglandina rosea (Fer.) Scroll Shell
(*Glandina truncata* (Gmelin))

143. Shell more than three times as high as wide 144.
Shell lower in proportion to width 146.

144. Shell lengthwise ribbed; about ¼″ high; Florida
Varicella gracillima (Pfeiffer)
(*Stenogyra gracillima* (Pfeiffer))
Shell practically smooth; southern states 145.

145. Whorls flattened; body whorl almost one-half as long as the shell; less than ¼″ high
Cecilioides acicula (Müller) Needle Shell
Whorls convex; body whorl much shorter; about ½″ high
Lamellaxis gracilis (Hutton)
(*Opeas gracile* (Hutton))
(*Stenogyra subula* (Pfeiffer))

146. Shell almost cylindrical, pupa-shaped; small ($1/4''$ or less); generally distributed 147.
Shell more tapering; becoming larger; southern states 148.

147. Aperture about as high as wide; shell dull; one of the *Pupillidae* lacking teeth and with a thin lip
Columella edentula (Drap.) Toothless Pupa
Aperture narrowed; shell shining
Cionella lubrica (Müller) Brilliant Snail
(*Cochlicopa lubrica* (Müller))

148. Apex broken off; shell plain light colored
Rumina decollata (Linn.)
Apex normally entire; shell usually, but not always, banded or streaked with color 149.

149. Body whorl inflated; aperture wide 150.
Body whorl and aperture more narrowed 151.

150. Aperture about one-half as long as the shell
Orthalicus reses (Say) Painted Florida Land Snail
(*Oxystyla undata* (Brug.))
Aperture less than one-half as long as the shell
Liguus fasciatus (Müller) Florida Tree Snail
(*Achatina fasciata* (Müller))

151. Small whorls of apex with minute upright and spiral lines crossing each other; aperture usually distinctly less than one-half the length of the shell; about $1''$ high
Drymaeus multilineatus (Say) Many-lined Florida Land Snail
Apex smooth, granulated, or vertically creased; aperture usually about one-half the length of the shell; often becoming larger — Giant Land Snails 152.

152. Interior of aperture dark colored
Bulimulus alternatus (Say)
Interior of aperture light colored
Bulimulus dealbatus (Say)

153. Lip definitely reflected 154.
Not so 189.

154. Minute shells with one or two ridges visible on the parietal wall parallel with the suture, and with several revolving ridges back within the aperture; eastern and central states
Strobilops labyrinthica (Say)
Not so 155.

155. With the lip continuing across the parietal wall in a raised, entering, V-shaped callus, making the aperture more or less ear-shaped (Many species, of which a few common ones are given) Ear-mouthed Wood Snails 156.
Not so 164.

156. .Shell with about seven whorls coiled almost in one plane; umbilicus showing the volutions; about $1/2''$; Florida 157.
Not so 158.

157. With a ridge within the last whorl; body whorl faintly keeled
Polygyra (Polygyra) cereolus (Muhlfeld)
No ridge within the last whorl; body whorl sharply keeled
Polygyra (Polygyra) septemvolva Say

158. With strong transverse ribs; about 1/4″; east-central states
Polygyra (Daedalochila) plicata Say
Not so 159.

159. Umbilical opening wide, showing all of the last volution; about 1/4″; southeastern states
Polygyra (Daedalochila) pustuloides (Bland)
Umbilical opening small or partly covered by the reflected lip 160.

160. Umbilicus partly covered by the edge of the aperture; about 1/4″; south-central states
Polygyra (Daedalochila) leporina (Gould)
Lip not covering umbilicus; about 3/8″ to 1/2″ 161.

161. With a tubercle or transverse ridge far back within the aperture on the base of the last whorl 162.
Not so 163.

162. With an upright tubercle on the base of the last whorl; central states
Polygyra (Daedalochila) dorfeuilliana Lea
With a transverse tubercle or ridge on the base of the last whorl; Texas
Polygyra (Daedalochila) hippocrepis (Pfeiffer)

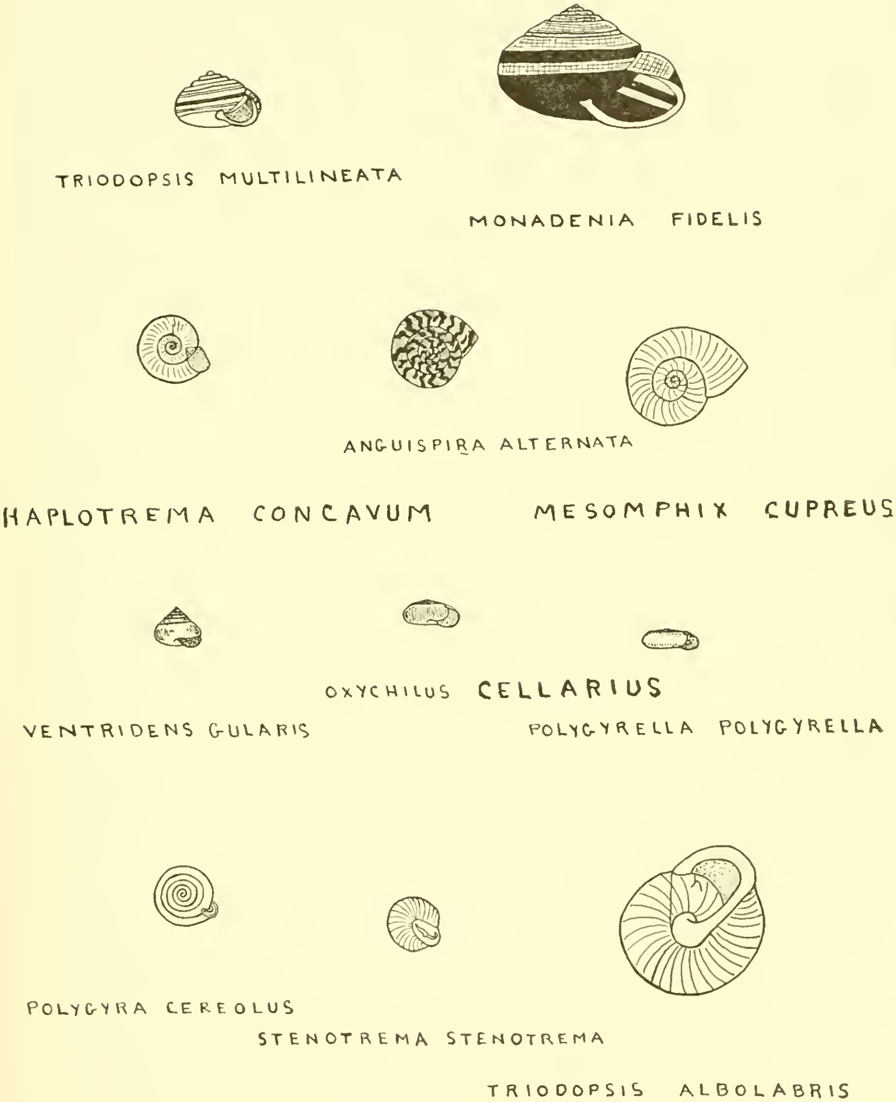
163. Teeth well developed; outer tooth on lip with a hook; southeastern states
Polygyra (Daedalochila) postelliana (Bland)
Teeth less well developed; with the parietal callus less elevated; no hook on the outer tooth on lip; southern states westward to Texas
Polygyra (Daedalochila) auriformis (Bland)

164. Aperture much narrowed, projecting scarcely beyond the outline of the body whorl; parietal wall with a long, thin, oblique tooth parallel to the lip (Many species, of which a few common ones are given here)
Narrow-mouthed Wood Snails 165.
Not so 168.

165. Outer lip not indented 166.
Lip indented 167.

166. Coils narrow and close; epidermis without hairs; lip not partly overlapping umbilicus; about 1/4″; eastern and central states
Stenotrema monodon (Rackett)
Coils wider and looser; epidermis with fine hairs; lip usually partly overlapping umbilicus; almost 1/2″; eastern and central states
Stenotrema fraternum (Say)

167. Parietal tooth incompletely overhanging lip, as seen from side view; about 1/4″; eastern and central states
Stenotrema hirsutum (Say)
Parietal tooth completely overhanging lip; about 3/8″; central states
Stenotrema stenotrema (Pfeiffer)


TRIODOPSIS MULTILINEATA
MONADENIA FIDELIS
ANGUISPIRA ALTERNATA
HAPLOTREMA CONCAVUM
MESOMPHIX CUPREUS
OXYCHILUS CELLARIUS
VENTRIDENS GULARIS
POLYGYRELLA POLYGYRELLA
POLYGYRA CEREOLUS
STENOTREMA STENOTREMA
TRIODOPSIS ALBOLABRIS

168. Lip thickened and well reflected; aperture toothed or toothless; shell unbanded in most but not all species 169.
Lip slightly reflected below; rarely with one tooth on the parietal wall; usually, but not always, with one or more revolving bands of color 189.

169. Minute (1/8″) shells; widely umbilicated; striate to ribbed; aperture toothless; generally distributed 170.
Not so 171.

170. Shell definitely ribbed
Vallonia costata (Müller)
Shell striate
Vallonia pulchella (Müller)

171. Mostly in Arizona and New Mexico; shells plain colored; moderate sized shells (Many species, of which this is representative)
Ashmunella ashmuni (Dall) White-lipped Desert Snail
Generally distributed, except in the two states mentioned; usually plain colored, but with bands of color in a few species; about 1/2″ to 1″ (Many species, formerly of the genus *Polygyra*, of which a few are given here) Large-mouthed Wood Snails 172.

172. Umbilicus closed 173.
Umbilicus open 180.

173. With a long, oblique tooth on the parietal wall, and usually with one or two teeth on the lip 174.
Toothless or with one small tooth on the parietal wall 177.

174. Umbilicus indented, sometimes slightly exposed; body whorl smoothly rounded; about 1/2″; central and southeastern states
Mesodon (Inflectarius) inflectus (Say)
Umbilicus concealed; body whorl usually somewhat angulate or keeled 175.

175. Lip usually with only one small tooth near the base of the aperture; 1/2″ to 3/4″; east-central states
Mesodon (Patera) appressus (Say)
Lip usually with two teeth 176.

176. Body whorl keeled; no hairs on epidermis; about 1″; central states
Triodopsis (Xolotrema) obstricta (Say)
Body whorl angulate; epidermis with fine hairs; about 3/4″ to 1″; eastern and east-central states
Triodopsis (Xolotrema) notata (Deshayes)
(*Polygyra denotata* (Ferussac))
(*Polygyra palliata* (Say))

177. Shell usually with many fine dark lines; umbilicus indented; about 3/4″ to 1″; central states
Triodopsis (Neohelix) multilineata (Say) Many-lined Wood Snail
Color not in fine revolving lines; umbilicus concealed 178.

178. With six whorls; height usually more than three-fourths width; $3/4''$ to $1''$; central states
Mesodon (Mesodon) elevatus (Say)
With less than six whorls; height usually less 179.

179. Height about 60% of width; about $1\frac{1}{4}''$; east of the Mississippi River
Triodopsis (Neohelix) albolabris (Say) White-lipped Wood Snail
Height about 70% of width; about $1''$; eastern and central states
Mesodon (Mesodon) zaletus (Binney)

180. Toothless or with one tooth on the parietal wall 181.
Aperture usually with one tooth on the parietal wall and with one or two teeth on the lip 185.

181. West Coast Shells 182.
In the eastern and central states 183.

182. Umbilicus almost covered by the reflected lip; about $5/8''$; California
Vespericola megasoma ("Dall" Pilsbry)
Umbilicus slightly covered by the reflected lip; about $5/8''$; Pacific states
Vespericola columbiana (Lea)

183. Umbilicus wide, about one-fifth the diameter of the shell; lip usually with a thickened area within the base of the aperture; with or without revolving bands of color; $1''$ to $1\frac{1}{4}''$
Allogona (Allogona) profunda (Say)
Lip turned back over a small umbilicus; lip without basal callus; plain colored 184.

184. Reflected lip wide and flat; with or without a tooth on the parietal wall; about $1''$
Mesodon (Mesodon) thyroidus (Say) White-lipped Wood Snail
Reflected lip narrower and more rounded; no tooth on the parietal wall; umbilicus smaller than in the preceding species; less than $3/4''$
Mesodon (Mesodon) clausus (Say)

185. With one tooth on the lip at the base of the aperture; about $1''$; eastern and central states
Mesodon (Appalachina) sayanus (Pilsbry)
(*Polygyra sayi* (Binney))
Typically with two teeth on the lip 186.

186. Tooth on parietal wall long and narrow, joined or almost so with the axial end of the lip; eastern and east-central states 187.
Tooth on parietal wall rather small; western species 188.

187. Aperture almost closed by the teeth; about $1/2''$
Triodopsis (Triodopsis) fraudulenta (Pilsbry)
Aperture not so constricted; about $1/2''$
Triodopsis (Triodopsis) tridentata (Say)

188. Umbilicus almost covered by the reflected lip; about $1/2''$; western states
Triodopsis (Cryptomastix) mullani (Bland & Cooper)

Umbilicus slightly covered by the reflected lip; about $1/4''$; California
Trilobopsis loricata (Gould)
(*Polygyra lecontii* (Lea))

189. Lip slightly expanded and reflected; many, but not all, of this group have one or more revolving bands of color 190.
Lip not reflected; shell unbanded in most, but not all, species 207.

190. Minute (not over $1/8''$) shells; epidermis usually shining or transversely ribbed, plain colored 207.
Moderate sized to large shells; usually banded 191.

191. Shell widely umbilicated, showing the volutions; lip continuing as a thin callus across the parietal wall 223.
Not so 192.

192. Shell about as high as wide; parietal wall rose colored; about $5/8''$; Florida
Cepolis varians (Menke)
Not so 193.

193. Introduced European species found mostly in the eastern states (one species in California); spire usually well elevated; umbilicus small or absent 194.
Native species 197.

194. Lip dark colored; no umbilicus
Cepaea nemoralis (Linn.) European Garden Snail
(*Helix nemoralis* (Linn.))
Lip light colored or shell with an umbilicus 195.

195. Shell shining and practically smooth, except for fine growth lines; usually dark banded, but sometimes plain yellowish
Cepaea hortensis (Müller)
Shell dull, pitted, usually dark banded 196.

196. With a narrow umbilicus; lip brownish
Helix pomatia Linn. Edible Snail of Europe
No umbilicus; lip white
Helix aspersa Müller Garden Snail of Europe

197. Shell usually with many fine dark lines; umbilicus indented but closed; central states
Triodopsis (*Neohelix*) *multilineata* (Say) Many-lined Wood Snail
Color bands usually wider and fewer; often with an umbilicus 198.

198. Width almost two times height; umbilicus rather wide, about one-fifth the diameter of the shell; with a small swelling on the lip within the base of the aperture; about $1''$ to $1\frac{1}{4}''$; eastern and central states
Allogona (*Allogona*) *profunda* (Say)
Not with the preceding combination of characters; southern and western states; moderate sized to large shells 199.

199. Southern species (east of Phoenix, Arizona); color usually grayish or with light bordered, dark stripes (Many species, of which a few representatives are given. For specific details see Pilsbry's *Land Mollusca of North America.*) 200.

Shells native to the Pacific states (in the southwest, west of Phoenix, Arizona); color usually, but not always, yellow to brown, dark banded (Many species. See Pilsbry's *Land Mollusca of North America* for specific details.) 202.

200. Umbilicus moderate, open; Sonora region (centering around Tucson, Arizona) Many species, of which this is representative)

Sonorella hachitana (Dall) Sonora Snail

Umbilicus narrow 201.

201. Lowest dark band starting at the top of the aperture; Texas and New Mexico

Humboldtiana ferrissiana Pilsbry

Lowest dark band entering aperture; Florida to Texas

Praticolella griseola (Pfeiffer)

202. Lowest dark band entering aperture; shell often angulate or keeled

Monadenia fidelis (Gray)

(*Epiphragmophora fidelis* (Gray))

Lowest dark band starting above the aperture; not keeled 203.

203. Usually smooth shells; Cal. and Arizona west of Phoenix

Micrarionta kelletti (Forbes)

(*Epiphragmophora kelletti* (Forbes))

Shells usually malleated, minutely granulated, or with fine hairs; Oregon and California 204.

204. Shells usually malleated; umbilicus small to absent 205.

Shells almost smooth or minutely granular; umbilicus moderate to small 206.

205. Shell depressed

Helminthoglypta (Helminthoglypta) tudiculata (Binney)

Shell almost as high as wide

Helminthoglypta (Helminthoglypta) nickliniana (Lea)

206. Shell relatively smooth, much depressed; desert species

Helminthoglypta (Helminthoglypta) graniticola Berry

Shell minutely granular, moderately depressed; coastal species

Helminthoglypta (Charodotes) traski (Newcomb)

207. Shell approaching pupa-shaped, plain colored, with umbilicus small to absent; not over 1/8″ 208.

Not so 212.

208. With about six whorls; shell smooth; umbilicus minute or absent 209.

With about four whorls; shell striate or ribbed; umbilicus small 210.

209. Height usually about the same as width; surface glossy; generally distributed, except for the southeastern U. S.

Euconulus fulvus (Müller) Beehive

Height usually greater than width; surface silky; south-central states
Euconulus chersinus (Say)

210. Umbilicus about one-seventh to one-eighth diameter of shell; tropical species
Thysanophora plagiotycha (Shuttleworth)
Umbilicus smaller in proportion to shell 211.

211. Shell definitely lengthwise ribbed; northern states
Zoögenetes harpa (Say)
Shell striate; tropical species in Florida
Pupisoma minus Pilsbry

212. Shell dull and opaque, or with a color pattern 213.
Shell glossy or translucent, plain colored 222.

213. Umbilicus narrow or very small 214.
Umbilicus moderate to broad 215.

214. Shell grayish, usually dark banded; about ½″; southern states
Praticolella griseola (Pfeiffer)
Shell brownish (with a light band encircling the body whorl in one species) 265.

215. With about four whorls; color plain; umbilicus showing the volutions 224.
With more whorls; with a color pattern in some species 216.

216. Color usually pale; shell usually banded or keeled; western species 217.
Color chestnut brown; with or without color markings; more generally distributed 218.

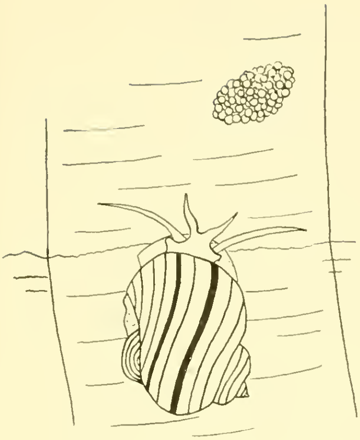
217. Lip slightly reflected in the lower columellar area; surface often slightly glossy; usually with a narrow, light-bordered, dark band; about ¾″; southwestern species, centering around Tucson, Arizona (Many species, of which a representative is given)
Sonorella hachitana (Dall) Sonora Snail
Lip often continuing as a thin callus across the parietal wall; surface dull, often banded or keeled; about 1″; western states (Many species, of which a representative is given)
Oreohelix strigosa (Gould) White Desert Snail

218. No color markings; about 5/16″ 219.
With color markings; usually larger 221.

219. Body whorl transversely rib-striate; aperture without teeth 220.
Body whorl smooth or spirally ridged, or with the aperture constricted by a tooth or callus on the parietal wall 247.

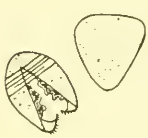
220. Umbilicus shallow; eastern and central states, except New England
Discus patulus (Deshayes) Brown Leaf Snail
(*Pyramidula perspectiva* (Say))
Umbilicus deep, with nearly upright walls; northwestern states
Radiodiscus abietum (Baker)

221. Shell dark banded; about 1″
Anguispira kochi (Pfeiffer) Banded Leaf Snail
(*Pyramidula solitaria* (Say))

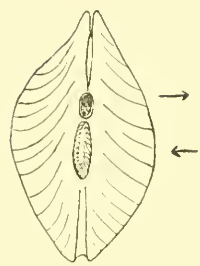


POMACEA AND EGG MASS

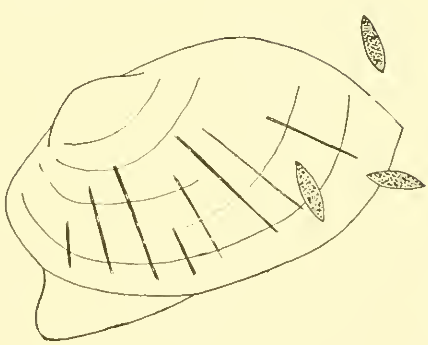
HELISOMA EGG MASS
ON GLASS OF AQUARIUM



GLOCHIDIA (MAGNIFIED)



REAR VIEW OF CLAM
TO SHOW SIPHONS



SIDE VIEW OF A CLAM TO SHOW FOOT
AND DISCHARGED GLOCHIDIA MASSES

Shell with broken, irregular, transverse bars; about 3/4″
Anguispira alternata (Say) Barred Leaf Snail
(*Pyramidula alternata* (Say))

222. Umbilicus broad, showing most of the volutions 223.
Umbilicus smaller to absent 265.

223. With somewhat less than five whorls 224.
With five to seven whorls 247.

224. With somewhat less than four whorls 225.
With four to four and one-half whorls 232.

225. Shell relatively smooth; about 1/8″ 226.
Shell definitely transversely striate or ribbed (in direction of growth lines); about 1/16″ 227.

226. Aperture oblique, flaring; surface of shell weakly crisscrossed or indented; southeastern states
Helicodiscus singleyanus (Pilsbry)
Whorls increasing more gradually; surface of shell smooth; California
Pristiloma shepardae (Hemphill)

227. Shell with many striae 228.
Shell with about twenty to sixty transverse ribs on the last whorl 229.

228. Shell low, flaring toward the oblique aperture; northeastern and north-central states
Striatura milium (Morse) Millet Seed
Shell more globose, increasing more gradually, with more regular aperture; more generally distributed
Punctum minutissimum (Lea)
(*Punctum pygmaeum* (Drap.))

229. Aperture entire 230.
Aperture interrupted or excised by parietal wall 231.

230. With about sixty ribs on last whorl; western states
Vallonia cyclophorella Sterki
With about thirty-five to forty ribs on the last whorl; east-central states to Ariz. and Utah
Vallonia perspectiva Sterki Vallonia

231. Lip definitely simple, thin; with about thirty-five to forty transverse ribs; northern states westward to Minn.
Striatura exigua (Stimpson)
Lip usually thickened within, at base; with twenty to thirty transverse, thin, erect bars, which may become wavy in dry shells; northern states westward to Michigan
Planogyra asteriscus (Morse) Star Snail

232. Shell discoidal, with fine revolving ridges around the body whorl; usually with small teeth back within the aperture; about 1/8″; widely distributed
Helicodiscus parallelus (Say)
(*Helicodiscus lineatus* (Say))
Not so 233.

233. Aperture narrowed by three almost evenly spaced teeth; about 1/16″; Okla. and Texas

Pilsbryna tridens Morrison

Not so 234.

234. Body whorl with ribs which continue across the base of the shell 235.

Shell smooth or with striae which become obscure on the base of the shell 238.

235. Aperture flaring, with the lip continuing as a thin callus across the parietal wall; California 236.

Aperture more circular; lip not continuing across the parietal wall 237.

236. Umbilicus very shallow, showing all of the volutions; about 3/8″; California mainland

Haplotrema caelatum (Mazyck)

Umbilicus wide and deep; about 1/4″; California and outlying islands

Haplotrema duranti (Newcomb)

237. Upper extremity of aperture starting at middle of body whorl; about 1/4″; widely distributed

Discus cronkhitei (Newcomb)

Upper extremity of aperture starting above the middle of body whorl; 1/8″; southwestern states

Radiodiscus millecostatus Pilsbry and Ferriss

238. Aperture flaring, with the lip continuing as a thin callus across the parietal wall; shell light horn colored; about 1/2″ to 3/4″ 239.

Lip not forming a callus across the parietal wall; seldom over 1/4″ 240.

239. About 1/2″; California

Haplotrema keepi (Hemphill) California Wood Snail

About 3/4″; eastern and central states

Haplotrema concavum (Say) Thin-lipped or White Wood Snail (*Circinaria concava* (Say))

240. Shell expanding rapidly in size, flaring toward the aperture 241.

Shell expanding more evenly 242.

241. Shell pinkish-brown, with fine transverse grooves; about 1/4″; Tenn. to Georgia

Retinella pentadelphia (Pilsbry)

Shell whitish, with fine striae; about 1/4″; northeastern and north-central states

Retinella binneyana (Morse)

242. Body whorl shouldered, with periphery near the top; aperture crescent-shaped; shell whitish; about 3/16″; Florida

Lacteoluna selenina (Gould)

Body whorl more evenly rounded; aperture almost circular 243.

243. Height definitely over one-half the width; southern states 244.

Height about one-half the width; more generally distributed 245.

244. Whitish; about 3/16″; Florida

Hojeda inaguensis (Weinland)

Brownish; about $\frac{1}{4}''$; Ariz., Texas and N. M.
Thysanophora horni (Gabb)

245. About $\frac{1}{8}''$; whorls four; shell pale; generally distributed
Hawaiia minuscula (Binney)
About $\frac{1}{4}''$; whorls about four and one-half 246.

246. Shell closely striate; shell pale; northeastern and north-central states
Zonitoides limatulus (Binney)
Shell scarcely striate; shell horn colored; generally distributed
Zonitoides arboreus (Say) Amber Leaf Snail

247. Shell almost discoidal; body whorl with fine revolving ridges which are beaded, rather than smooth as in *H. parallelus* (Choice 232); about $\frac{1}{8}''$; S. C.
Clappiella saludensis (Morrison)
Not so 248.

248. Aperture constricted by a thickening within the lip and by a parietal callus or tooth; shell almost discoidal, with six to eight whorls 249.
Aperture not so 250.

249. Spire concave; with a parietal callus; $\frac{1}{4}''$; California
Ammonitella yatesi (Cooper) Yates's Snail
Spire flat to convex; with a tooth on the parietal wall; $\frac{1}{2}''$; northwestern U. S.
Polygyrella polygyrella (Bld. and Cooper)

250. Body whorl regularly expanded 251.
Body whorl flaring toward the aperture to become about twice as wide as the whorl next to it 256.

251. With six or seven whorls 252.
With about five whorls 253.

252. Body whorl with radial rows of small teeth within the base and usually visible through the shell; lip thin; about 3/16″; central states
Paravitrea significans (Bland)
With a lamella or thick callus at base of aperture; about $\frac{1}{2}''$; Tenn. to Ala.
Ventridens lasmodon (Phillips)

253. Body whorl toothed within, near the aperture; about $\frac{1}{8}''$; Tenn. to Ala. 254.
Not so 255.

254. Aperture toothed within, on columellar and parietal regions; Tenn.
Pilsbryna aurea Baker
Body whorl wth a series of four double-pointed teeth within last half; Tenn. to Ala.
Clappiella aldrichiana (Clapp)

255. Spire flattened; usually with slightly over five whorls; about 3/16″; western states
Microphysula ingersolli (Bland)
Spire somewhat elevated; usually with slightly under five whorls; about $\frac{1}{4}''$; generally distributed
Zonitoides arboreus (Say) Amber Leaf Snail

256. With seven whorls; young (only) with teeth within body whorl; about $\frac{1}{4}''$; Virginia and Kentucky
Paravitrea pontis Baker
With five to six whorls 257.

257. Lip usually continuing as a thin callus across the parietal wall 258.
Not so 261.

258. Shell light yellowish 259.
Shell darker 260.

259. Lip sinuous, usually indented above and slightly expanded below; whorls striate within umbilicus; $\frac{1}{2}''$ to $\frac{3}{4}''$; eastern and central states
Haplotrema concavum (Say) Thin-lipped or White Wood Snail
(*Circinaria concava* (Say))
Lip not so; shell smooth within umbilicus; about $\frac{5}{8}''$; Wash. and Oregon
Megomphix hemphilli (Binney)

260. Lip usually sinuous above and thickened below; shell dark greenish, with light streaks; about $\frac{3}{4}''$ to $1''$; Cal. to Wash. and Idaho
Haplotrema vancouverense (Lea) Vancouver Wood Snail
Lip not so; shell very dark brown; about $1\frac{1}{4}''$ to $1\frac{1}{2}''$; Cal.
Glyptostoma newberryanum (Binney)

261. Shell definitely much lighter colored below than above; about $\frac{5}{8}''$; an introduced European species
Oxychilus draparnaldi (Beck)
Shell more uniformly colored; smaller 262.

262. Young specimens toothed within body whorl; adults darkish horn colored; about 3/16″; Tenn.
Pilsbryna castanea Baker
Body whorl not toothed within; usually light horn colored or pink tinted 263.

263. Adults $\frac{1}{4}''$; shells light or pink tinted; Tenn. to Arkansas
Paravitrea petrophila (Bland)
Adults about 3/16″ 264.

264. Pinkish; Virginia
Retinella virginica Morrison
Horn colored; central states
Retinella wheatleyi (Bland)

265. With two to three whorls 266.
With four or more whorls 268.

266. With a small umbilicus; shell heliciform; about $\frac{1}{8}''$; northeastern and north-central states to N. C.
Striatura ferrea Morse
No umbilicus; last whorl greatly expanded; larger 267.

267. Shell darkish; adults about $\frac{3}{4}''$; Great Smokies
Vitrinizonites latissimus (Lewis)
Shell light; adults about $\frac{1}{4}''$; northeastern states
Vitrina limpida Gould Glass Snail

268. Last whorl expanded toward the aperture so that it is about twice as wide as the whorl next to it 269.
Body whorl scarcely expanded 282.

269. Interior of shell of a definitely different color from the surface of the shell, usually purplish or with a whitish deposit within lip; large shells, adults being ¾″ to 1″; eastern and central states Large Leaf Snails 270.
Interior of shell not noticeably different from the surface of the shell 275.

270. Height about or less than half the diameter 271.
Height usually considerably more than one-half the diameter 272.

271. Spire striate
Mesomphix subplanus (Binney)
Spire smooth
Mesomphix inornatus (Say)

272. Umbilicus round, about one-sixth diameter of shell; apex usually worn
Mesomphix (Omphalina) cupreus (Raf.)
Umbilicus narrowed, smaller; apex not normally worn 273.

273. Aperture scarcely wider than high, purple near columellar area
Mesomphix (Omphalina) friabilis (Binney)
Aperture usually noticeably wider than high 274.

274. Body whorl with fine spiral lines of fine papillae
Mesomphix vulgatus Baker
Spiral lines on body whorl smooth or obscure
Mesomphix perlaevis (Pilsbry)
(*Mesomphix laevigatus* Beck)

275. Shell glassy-smooth, with flat spire; about ½″ to ¾″; northwestern U. S.
Megomphix hemphilli (Binney)
Shell glossy to striate; spire low; smaller 276.

276. Shell glossy, scarcely striate; introduced European species often found around buildings and in greenhouses 277.
Shell regularly striate or grooved; native species 278.

277. Animal almost black; shell about ¼″; smelling of garlic
Oxychilus alliarius (Miller)
Animal gray; shell about ⅜″
Oxychilus cellarius (Müller) Cellar Snail

278. With seven whorls; northeastern U. S.
Retinella sculptilis (Bland)
With four to five whorls 279.

279. Umbilicus very minute; eastern and central states
Retinella indentata (Say) Large-mouthed Leaf Snail
Umbilicus small 280.

280. With five whorls; central states
Retinella wheatleyi (Bland)
With four whorls 281.

281. Radial grooves extending on base of shell; eastern states
Retinella rhoadsi (Pilsbry)

Base of shell almost smooth; generally distributed
Retinella electrina (Gould)
(*Vitrea hammonis* (Ström))

282. With four or five whorls 283.
With five and one-half to eight whorls 289.

283. Umbilicus moderately small 284.
Umbilicus tiny; shell about 1/16″ to 1/8″ 286.

284. Usually with parietal and columellar lamellae; about 1/8″; Appalachian region
Pilsbryna aurea Baker
No teeth within aperture 285.

285. Shell rib-striate; less than 1/8″; western U. S.
Punctum conspectum (Bland)
Shell with weak growth lines; about 1/4″; generally distributed
Zonitoides nitidus (Müller) Yellow Leaf Snail

286. Eastern and southern species 287.
In the Pacific states 288.

287. With distinct, fine spiral sculpture on the body whorl; about 1/8″; Florida and Texas
Guppya gundlachi (Pfeiffer)
Spiral sculpture rather obscure; about 1/16″; eastern states
Guppya sterkii (Dall)

288. Spire flattened; about 1/16″
Pristiloma nicholsoni Baker
Spire elevated; about 1/8″
Pristiloma chersinella (Dall)

289. Lip thickened by a white callus or teeth within 290.
Lip simple 297.

290. No umbilicus; with five and one-half whorls; about 1/8″; Pacific states
Pristiloma lansingi (Bland)
With a small umbilicus; with five and one-half to eight whorls; about 1/4″ to 1/2″; eastern and central states to Texas — Moss Snails 291.

291. Umbilicus moderately small, about one-eighth diameter of shell; spire rather low 292.
Umbilicus tiny, sometimes narrowed; spire more elevated in most species 293.

292. Aperture toothless; with about five whorls; east-central states
Ventridens elliotti (Redfield)
Usually with small teeth within aperture; usually with about six whorls; northeastern states
Ventridens suppressus (Say)

293. With a light band encircling the body whorl; east of the Mississippi
Ventridens intertextus (Binney)
Shell plain colored 294.

294. Usually with seven or eight whorls; aperture usually toothed within 295.
Usually with six or seven whorls; aperture usually toothless 296.

295. Upper whorls ribbed; about 1/4″; south-central states (Ind. to Ala.)
Gastrodonta interna (Say)
Whorls with growth lines only; about 3/8″; Penna. to Ala.
Ventridens gularis (Say)

296. Spire rather low; east of the Mississippi
Ventridens demissus (Binney)
Spire more elevated (height almost three-fourths width); westward to Okla.
Ventridens ligera (Say)

297. Umbilicus absent or extremely minute; about 1/8″; northwestern states 298.
With a small umbilicus; with lamellae or radial rows of teeth within base of last whorl and usually visible through the shell, in young specimens, sometimes persisting in the adult; about 1/8″ to 1/4″; eastern and central states to Texas 299.

298. Spire somewhat elevated; with radial grooves in shell
Pristiloma stearnsi (Bland)
Spire depressed; shell almost smooth
Pristiloma subrupicola (Dall)

299. With eight whorls
Paravitrea andrewsae (Binney)
With five or six whorls 300.

300. Body whorl irregularly striate or grooved 301.
Body whorl with close, evenly spaced striae or grooves 302.

301. Young often with pairs of teeth within; from western Ill. and Tenn. to Okla.
Paravitrea significans (Bland)
Often without teeth in both young and adult; from eastern Ill. and Tenn. to N. C.
Paravitrea capsella (Gould)

302. With radial rows of teeth within base of body whorl and often visible through the shell; Maine to Ala. and Arkansas
Paravitrea multidentata (Binney) Toothed Leaf Snail
Without teeth; often with one or more lamellae within base of body whorl; Tenn. to N. C. 303.

303. Body whorl with minute spiral lines; with or without internal lamellae
Paravitrea walkeri (Pilsbry)
Body whorl without spiral lines; usually with internal lamellae
Paravitrea lamellidens (Pilsbry)

KEY TO THE PRINCIPAL GENERA AND SPECIES OF CLAMS AND CLAM-LIKE MOLLUSKS

1. Shell without nacre (mother-of-pearl) except around the edges, outside of the pallial line; cardinal teeth situated under the beaks, with the lateral teeth both before and behind; shell seldom reaching one inch in length; generally distributed Finger-nail Shells 2.

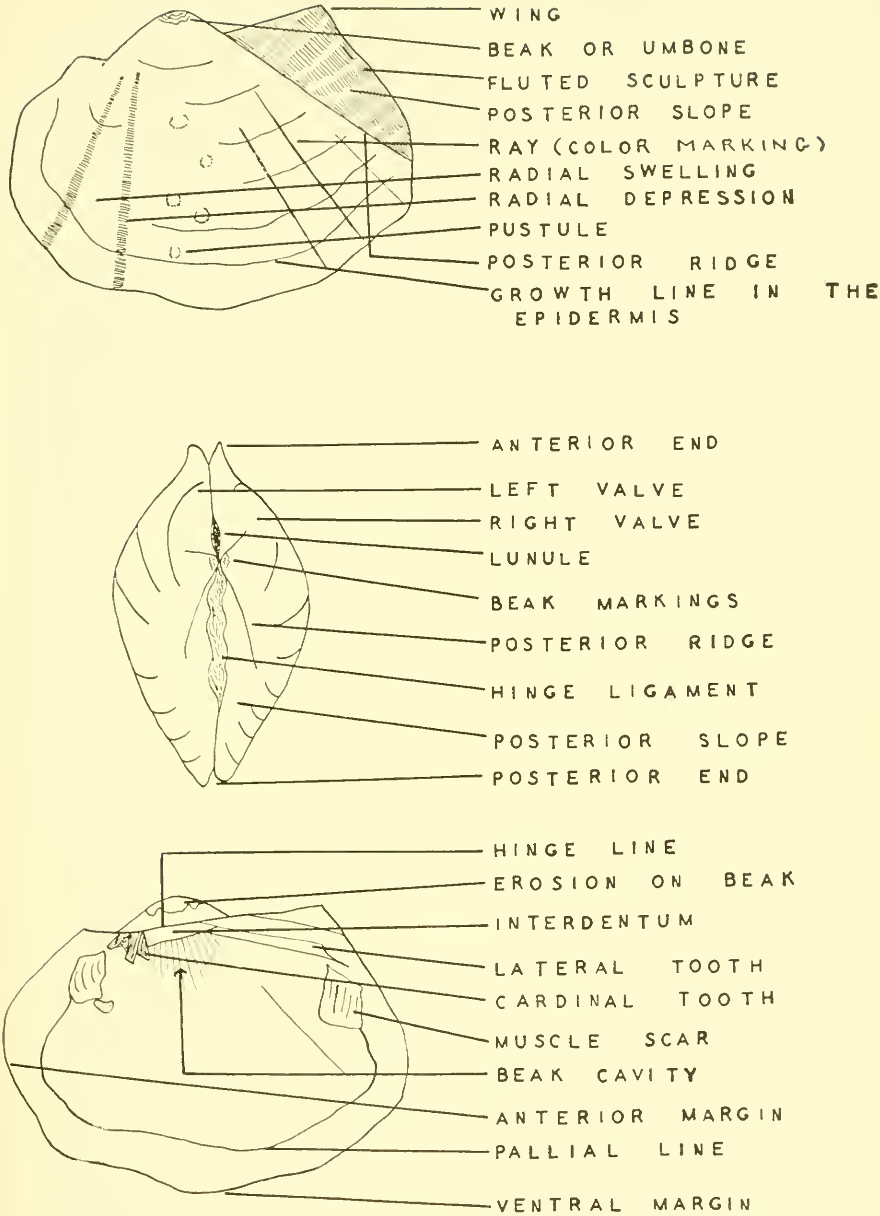


DIAGRAM OF A CLAM SHELL

Shell lined with nacre; cardinal teeth (strictly, pseudocardinals) under or before beaks, with the lateral teeth posteriorly; usually becoming larger True Clams or Mussels 4.

2. Anterior end longer than the posterior; apparently only one siphon; shell triangular
Pisidium Pfeiffer
Anterior end shorter than the posterior; with two distinct siphons; shell ovoid or rectangular 3.

3. Embryonic part of shell distinct from the adult growth; shell rectangular
Musculium Link
Not so, shell ovoid
Sphaerium Scopoli

4. Lateral teeth blurred or absent 5.
Lateral teeth complete 34.

5. No indication of cardinal teeth 6.
Cardinal teeth present or represented by minute tubercles or swellings of the hinge line 16.

6. Shell almost cylindrical; with fine, concentric umbonal markings; Mississippi and St. Lawrence drainages
Anodonta ferussaciana Lea Cylindrical Paper Shell
Anodontoides ferussacianus (Lea)
Shell thin below; umbonal markings usually double looped, nodulous or parallel bars 7.

7. Shell almost flat, not much longer than high, winged both anteriorly and posteriorly and gaping at both ends; central states
Anodonta suborbiculata Say Flat Paper Shell
Utterbackiana suborbiculata (Say)
Not so 8.

8. Umbones very flat, looking as if they had been sliced off; Mississippi drainage
Anodonta ohiensis Raf. Paper Shell
Utterbackia imbecillis Say
Umbones rounded 9.

9. Umbones swollen and extending above the hinge line; umbonal markings usually nodulous (with minute tubercles); most of U. S. except the extreme east and the Rocky Mt. area and westward
Anodonta grandis Say Floater
Umbones not so much elevated; umbonal markings not usually nodulous 10.

10. Dorsal margin not winged posteriorly; eastern states 11.
Dorsal margin usually straight and sloping slightly upwards to form a low wing posteriorly; central, western or southeastern states 13.

11. No marked posterior ridge; posterior slope rounded; nacre dull silver; not common
Anodonta marginata Say Silver Paper Shell
Posterior ridge somewhat double; nacre bluish to salmon 12.

12. Posterior ridge ending below the mid line; nacre thickened at the margin and anteriorly, darker in the cavities; not common
Anodonta implicata Say
Posterior ridge ending at about the mid line; shell thin throughout; nacre bluish; common
Anodonta cataracta Say Eastern Floater

13. Usually with faint wavy rays (color markings); southeastern states
Anodonta couperiana Lea Wavy-rayed Floater
Usually rayless or with a few faint rays; western species **14.**

14. Posterior ridge curved slightly upwards and ending in a slight turned-up projection
Anodonta wahlametensis Lea
Posterior ridge straight **15.**

15. Shell very thin; beak sculpture double-looped
Anodonta impura Say Western Floater
Shell more solid; beak with almost straight, parallel markings
Anodonta oregonensis Lea Oregon Floater

16. Shell fluted on posterior slope **17.**
Posterior slope not fluted **19.**

17. Length about two times the height; central states
Lasmigona costata (Raf.) Fluted Shell
Length not over one and one-third times the height **18.**

18. With a double row of pustules down the center; Mississippi and Ohio drainages and west to Texas
Arcidens confragosa (Say) Rock Pocketbook
Posterior half of shell with oblique wrinkles or folds; Arkansas to Oklahoma
Arkansia wheeleri Walker and Ortmann

19. Shell not much longer than high, flattened, and with a low or high posterior wing; central states
Lasmigona complanata (Barnes) White Heel Splitter, Hatchet-back
Not so 20.

20. With two distinct posterior ridges; Cumberland and Tennessee Rivers
Pegias fabula (Lea)
Only one or no pronounced posterior ridge 21.

21. Little or no posterior ridge; shell lengthened 22.
With a posterior ridge; shell oval or triangular 28.

22. Cardinal teeth heavy; nacre tinged with red or purple; most of U. S., in mountain streams
Margaritana margaritifera (Linn.) River Pearl Mussel
Cardinal teeth very small or blurred; nacre white, salmon or purple-tinted 23.

23. Shell gaping before and behind; shell slightly twisted when viewed from above or below; rare 24.
Shell not normally gaping; not twisted 25.

24. Outline fairly even; shell winged posteriorly in young; umbonal markings several fine double loops; rays (color markings) complete; nacre purplish or salmon; upper Mississippi drainage

Lampsilis leptodon (Raf.)

Proptera (*Leptodea*) *leptodon* (Raf.)

Shell narrowed to a point posteriorly; not winged; umbonal markings several coarse folds; rays usually broken; nacre bluish or purplish, darker in the cavities; Ohio, Cumberland and Tennessee River drainages

Hemistena lata (Raf.) Twisted Shell

Lastena lata Raf.

25. Shell about two and one-half times as long as high, arcuate; central states

Cumberlandia monodonta (Say) Spectacle Case

Shorter 26.

26. Shell very evenly long-elliptical; with parallel beak markings bent upwards in the middle; usually less than two inches long; central states

Simpsoniconcha ambigua (Say)

Shell more irregular; with concentric beak markings; becoming larger 27.

27. Little indication of cardinal tubercles; ventral margin almost straight; umbonal markings fine; Mississippi and St. Lawrence drainages

Anodonta ferussaciana Lea Cylindrical Paper Shell

Anodontoides ferussacianus (Lea)

Cardinal teeth represented by small tubercles or swellings of the hinge line; ventral margin curved; umbonal markings coarse; generally distributed

Strophitus undulatus (Say) Squaw-foot, Orange Peel

including *Strophitus rugosus* (Swainson)

28. Anterior end much narrower than the rest of the shell; rays (color markings), if present, fine or inconspicuous 29.

Anterior end not conspicuously narrow; with or without rays 30.

29. Shell long and wedge-shaped; beaks low; nacre brownish or purple; western states

Gonidea angulata (Lea)

Shell triangular; beaks full and high; nacre bluish; Georgia

Alasmidonta arcula (Lea)

30. Posterior end flattened and corrugated; beaks elevated above the hinge line; rays usually broken; central states

Decurambis marginata (Say) Elk-toe

Alasmidonta marginata Say

Posterior end slightly or obliquely truncated; not corrugated on posterior slope; beaks not much elevated; rays not usually broken 31.

31. Posterior end obliquely truncated; epidermis dull, with wavy rays; north-central and eastern states

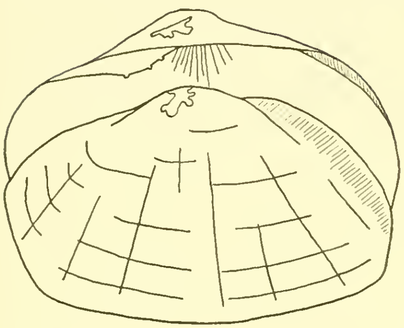
Alasmidonta calceola (Lea) Slipper Shell

Posterior end slightly truncated and pinched upwards to the dorsal margin; epidermis shining, with narrow and wide rays, except in old shells, or dull, with obscure rays 32.

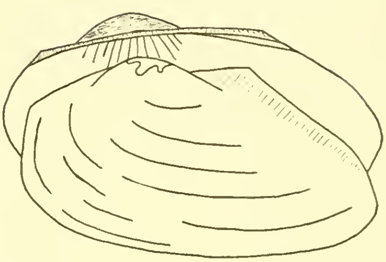
SPHAERIUM

PISIDIUM

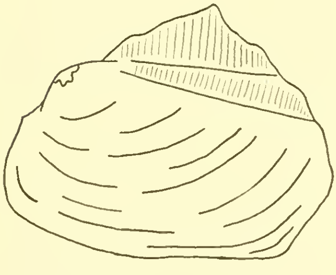
MUSCULIUM



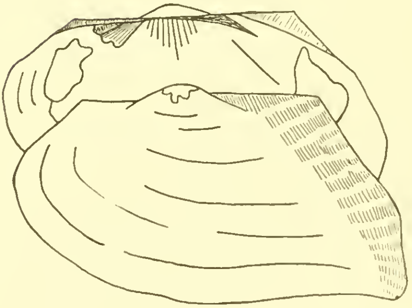
STROPHITUS UNDULATUS



ANODONTA GRANDIS



PROPTERA ALATA



LASMIGONA COSTATA

32. Epidermis shining, with narrow and wide rays, except in old shells; teeth heavy; Atlantic drainage
Alasmidonta undulata (Say)
Epidermis dull, with obscure rays; teeth small 33.

33. With one to three blurred laterals in each valve; shell pointed behind; eastern states
Alasmidonta heterodon (Lea)
Laterals almost completely absent; shell blunt behind; Tennessee River drainage
Alasmidonta badia (Raf.)
Alasmidonta holstonia (Lea)

34. Shells with ribs, pustules, knobs or spines 35.
Shell relatively smooth, except for the posterior ridge 55.

35. Shell ridged (ridges not crowned by rows of knobs or pustules) 36.
Shell with pustules, knobs or spines 40.

36. Shell with but two ridges, one median and one posterior, with a much depressed area between; Ohio River drainage
Dysnomia flexuosa (Raf.) Folded Shell
Dysnomia foliata (Hild.)
Shell with three or more ridges on each valve 37.

37. With a sharp posterior ridge; nacre purple, red or coppery; south-central states
Amblema dombeyana (Val.) Bank Climber
Plectomerus dombeyana (Val.)
Little or no posterior ridge; nacre usually white, tinted towards the post-basal angle 38.

38. Lower umbonal region with small zigzag ridges or indications of pustules; shell getting to be large and heavy; Mississippi drainage
Amblema gigantea (Barnes) Giant Washboard, Sugar Shell
Megalonaias gigantea (Barnes)
Lower umbonal region relatively smooth except for the beginnings of the large oblique folds; shell smaller; Mississippi drainage 39.

39. Umbones reaching well above the hinge line; larger rivers of the Mississippi drainage
Amblema plicata (Say) Blue Point
(*Amblema peruviana* (Lamarck))
(*Amblema rariplicata* (Lamarck))
Umbones reaching scarcely above the hinge line; smaller streams of the Mississippi drainage
Amblema plicata-costata Raf. Washboard, Three Ridge
Amblema costata Raf.

40. With long upright spines; Georgia
Canthyria spinosa (Lea) Spiny Shell
Elliptio spinosus (Lea)
With knobs or tubercles 41.

41. Length over one and one-half times height; anterior part with or without pustules 42.
Length usually less; no pustules anteriorly 43.

42. Anterior part thickly pustulated; epidermis rayless; Mississippi drainage to Texas

Quadrula verrucosa (Raf.) Pistol-grip, Buckhorn
Tritogonia verrucosa (Raf.)

Anterior part scarcely pustulate; epidermis with broken rays (color markings) or green spots; central states

Quadrula cylindrica (Say) Rabbit-foot

43. Pustules or knobs grouped in more or less definite radial rows (If there is any indication of radial grouping, take this choice) 44.

Pustules scattered over shell 51.

44. Pustules mostly in one row down the center of each valve 45.

Pustules in two or more rows 49.

45. Posterior slope with pustules which are usually arranged in rows; epidermis tawny to brown, with green spots; most of the Mississippi drainage

Quadrula metanevra (Raf.) Monkey-face

Posterior slope not pustulate 46.

46. Interdentum very wide and flat; with a hump below each umbone; rays (color markings) spotted or broken and of varying widths; Tennessee and Cumberland Rivers

Dromus dromas (Lea) Dromedary Shell

Interdentum moderate to narrow; usually with a row of knobs down each valve 47.

47. With about three knobs on one valve distinctly alternating with those on the other; epidermis with fine broken or wavy rays; most of the U. S. except the extreme eastern and western states

Obliquaria reflexa Raf. Three-horned Warty-back

Usually with a row of knobs on each valve arranged almost opposite each other or more-or-less irregularly; postbasal margin produced; rayless or with faint rays (color markings) 48.

48. Epidermis smooth, with faint rays; Ohio River drainage

Dysnomia torulosa (Raf.)

Epidermis in very coarse, concentric folds, usually rayless; central states

Pleurobema cyphyum (Raf.) Bull-head, Sheep-nose
Plethobasus cyphyus (Raf.)
(*Plethobasus aesopus* (Green))

49. With broken green rays; Ohio, Cumberland and Tennessee Rivers

Cyprogenia stegaria (Raf.) Fan Shell
Cyprogenia irrorata (Lea)

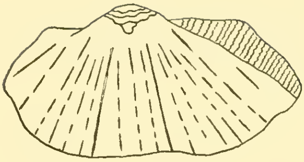
Usually rayless; central states 50.

50. Shell rounded; with several large pustules in two more or less distinct rows; postdorsal and dorso-posterior edges forming a right angle; cardinal plate and laterals forming almost a right angle

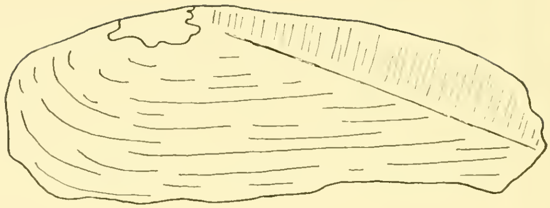
Quadrula nodulata (Raf.) Warty-back
Quadrula pustulata (Lea)

Shell angular; pustules many and small; angles, as above, greater than a right angle

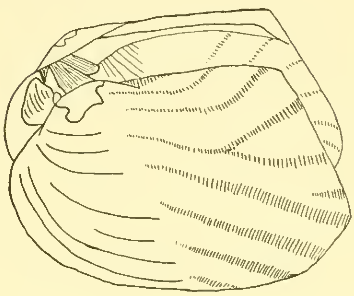
Quadrula quadrula Raf. Maple-leaf



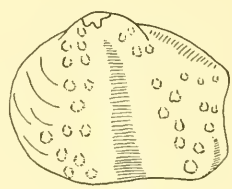
DECURAMBIS MARGINATA



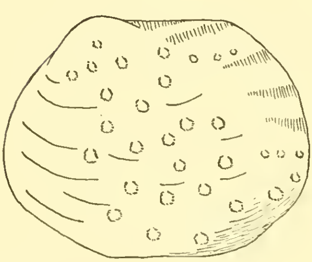
MARGARITANA MARGARITIFERA



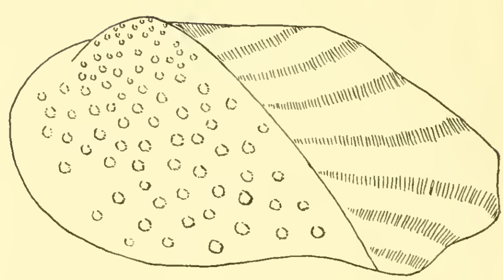
AMBLEMA PLICATA-COSTATA



QUADRULA QUADRULA



QUADRULA PUSTULOSA



QUADRULA VERRUCOSA

51. Shell with broken green rays; posterior ridge developed, with a radial depression before and behind; Ohio, Cumberland and Tennessee Rivers

Cyprogenia stegaria (Raf.) Fan Shell

Cyprogenia irrorata (Lea)

Shell scarcely rayed; posterior ridge low, with a radial depression behind 52.

52. Umbonal markings fine; nacre white or pinkish 53.

Umbonal markings coarse; nacre purplish 54.

53. Epidermis greenish; dorsal margin almost straight; Mississippi drainage

Quadrula pustulosa (Lea) Pimple-back

Epidermis reddish-brown; dorsal margin curved; Ohio, Cumberland and Tennessee Rivers

Quadrula striata (Raf.)

Plethobasus cooperianus (Lea)

54. Pustules scattered irregularly; beaks anterior; Mississippi drainage

Quadrula tuberculata (Raf.) Purple Pimple-back

Cyclonaias tuberculata (Raf.)

Pustules in zigzag lines; beaks central; Georgia

Quadrula securiformis (Conrad)

55. With a long projection from the interdentum of one valve which fits into a depression in the interdentum of the other; shell lengthened, slightly winged posteriorly; generally distributed, except for the Atlantic and Pacific states

Lasmigona viridis (Raf.)

Lasmigona compressa (Lea)

Not so 56.

56. Shell winged posteriorly, moderately full to flat, usually not much longer than high 57.

Not so 60.

57. Valves moderately full; nacre purple; south-central states

Proptera purpurata (Lamarck) Purply

Shell flattened 58.

58. With a low wing anteriorly; epidermis polished, usually rayless; shell gaping posteriorly; nacre purplish; Ohio and Mississippi valleys; New York to Texas

Proptera laevissima (Lea) Smooth Heel-splitter

Leptodea laevissima (Lea)

Little or no wing anteriorly; epidermis rayed (with color markings) or with many growth lines; not usually gaping; nacre similar or not 59.

59. Epidermis green or dark; nacre pink, salmon or purple; cardinal teeth sharp-edged; Mississippi and St. Lawrence drainage

Proptera alata (Say) Pink Heel-splitter

Epidermis yellowish; nacre silvery, often pink-tinted; cardinal teeth small and dull; widely distributed, not reaching the far western states

Lampsilis fragilis (Raf.) Fragile Paper Shell

Leptodea fragilis (Raf.)

60. Length of shell more than two times the height 61.
Length less than two times the height 70.

61. Shell usually with small transverse ridges on the posterior slope; epidermis with broken rays (color markings); nacre bluish to salmon tinted; less than three inches; Tennessee and Alabama River drainage
Medionidus conradicus (Lea)
No transverse ridges on the posterior slope; becoming larger 62.

62. Laterals much removed from the cardinals, with no connecting plate; posterior ridge ending below the mid line, with two radiating furrows on the flattened posterior slope; umbonal markings six to ten concentric ridges curved up and drawn together behind; central states
Elliptio tetralasmus (Say)
Uniomerus tetralasmus (Say)
Either with the laterals connected with the cardinals by an interdentum or with the posterior ridge ending at the mid line or above; umbonal markings not as above 63.

63. Posterior ridge ending at a point midway or more up from the base; beak cavity shallow but impressed; umbonal markings double-looped and open behind 64.
Posterior ridge ending at the posterior basal angle; little, if any, beak cavity; umbonal markings irregular bars 67.

64. Shell with a curved posterior ridge ending in a slightly narrowed area; epidermis dull; Atlantic drainage
Lampsilis nasuta (Say) Beaked Shell
Ligumia nasuta (Say)
Posterior ridge straight; posterior end evenly rounded or pointed 65.

65. Epidermis olive, brown or black, rayed only in young; shell heavy; with three to five double loops on the umbones; nacre purplish to salmon; central and eastern states
Lampsilis recta (Lamarck) Black Sand Shell
Ligumia recta (Lamarck)
Epidermis clear yellowish or darker and with rays; shell thinner; umbones with eight to ten fine double loops; nacre white to salmon tinted; Mississippi drainage and Gulf states 66.

66. Epidermis clear yellowish
Lampsilis teres (Raf.) Yellow Sand Shell
Lampsilis anodontoides (Lea)
Epidermis greenish, rayed
Lampsilis teres-fallaciosa Simpson Slough Sand Shell
Lampsilis fallaciosa Simpson

67. Epidermis tawny; rays, if present, broken; nacre white, with oblique folds; east-central states
Ptychobranchus fasciolare (Raf.) Kidney Shell
Epidermis dull to dark; rays, if present, complete; nacre usually purplish 68.

68. Hinge plate thin; shell usually very long and narrow, often as much as three times as long as high; east-central states
Elliptio productus (Conrad)

Hinge plate moderate to heavy; shell slightly over two times as long as high 69.

69. Shell rhomboid; dorsal margin meeting the posterior margin at an angle; hinge plate moderate; nacre purplish, often coppery tinted; Atlantic drainage

Elliptio complanatus (Dillwyn) Spike

Shell elliptical; dorsal margin sloping smoothly into the posterior margin; hinge plate thick and heavy; nacre usually purple; most of U. S. except the Pacific states

Elliptio dilatatus (Raf.) Lady-finger

70. Shell with a heavy hinge plate, with the larger cardinal tooth in the left valve directed toward the postbasal angle and almost parallel with the laterals; outline of shell almost circular or triangular 71.

Cardinal teeth slender or directed downwards or anteriorly at almost a right angle or more with the laterals; outline various 83.

71. With a long, flat posterior slope 72.

Posterior ridge faint or double; posterior slope rounded or low 74.

72. Umbones full; epidermis often with broken rays (color markings); eastern and east-central states

Pleurobema mytiloides Raf. Club Shell

Pleurobema clava (Lamarck)

Umbones flattened 73.

73. Epidermis yellowish, with rays which may be broken up into squarish blotches; nacre white; central and east-central states

Plagiola lineolata (Raf.) Butterfly Shell

Epidermis dark; nacre purplish; Mississippi drainage

Elliptio niger (Raf.) Elephant's Ear

Elliptio crassidens (Lamarck)

74. Nacre usually purplish 75.

Nacre usually white or pink 76.

75. Shell almost circular, except for the very prominent beaks; no radial swelling or depression; Ohio, Cumberland and Tennessee drainages

Obovaria retusa (Lamarck) Golf-stick

Shell more angular; usually with a radial swelling or depression before the posterior ridge; Ohio River drainage

Dysnomia sulcata (Lea) Cat's Paw

76. Lunule not extending before the beaks, with the anterior margin scarcely or not projecting forward 77.

Lunule projecting to a point well before the beaks 78.

77. Beaks shallow; posterior muscle scars D-shaped; with a small anterior cardinal in the right valve; east-central and central states

Obovaria olivaria (Raf.) Hickory-nut

Beaks narrowed under cardinals; posterior muscle scars almost circular; no anterior cardinal in the right valve; Mississippi drainage

Quadrula antrosa (Raf.) Nigger-head

Fusconaia ebenus (Lea)

78. Shell oval; epidermis somewhat polished, with faint rays (color markings); Mississippi River
Lampsilis higginsii (Lea) Higgin's Eye
Shell more triangular; epidermis somewhat cloth-like or satiny, with obscure or no rays 79.

79. No radial swelling or depression before the posterior ridge; Tennessee drainage
Quadrula dollabelloides (Lea)
Lexingtonia dolabelloides (Lea)
With radial swelling or depression before the posterior ridge 80.

80. Beak cavities narrowed up under the hinge line 81.
Beak cavities rounded, moderate to shallow 82.

81. Posterior base distinctly drawn out to a blunt point; central states
Quadrula obliquata (Raf.)
Pleurobema cordatum pyramidatum (Lea)
Posterior base more rounded; central states
Quadrula cordata (Raf.) Ohio Pig-toe
Pleurobema cordatum (Raf.)
(*Pleurobema obliquum* (Lamarck))

82. Epidermis almost smooth; south-central states
Obovaria curta (Lea)
Pleurobema curta (Lea)
Epidermis in coarse, concentric folds; east-central states
Pleurobema detectum (Frierson)
Plethobasus cicatricosus (Say)

83. Shell almost two times as long as high 84.
Shell shorter 98.

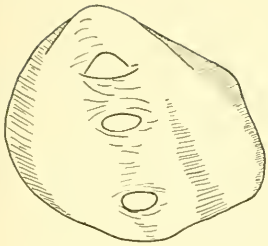
84. Shining yellow, rayless; Mississippi drainage and Gulf states
Lampsilis teres (Raf.) Yellow or Slough Sand Shell
Lampsilis anodontoides (Lea)
Dark or with rays (color markings) 85.

85. Epidermis dull to dark; faint rays, if present, confined to the posterior slope 86.
Epidermis shining or with rays 90.

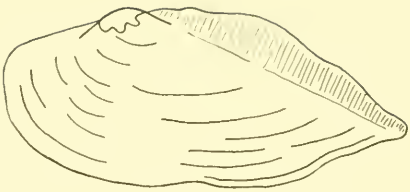
86. Beak cavity shallow; with a moderate posterior ridge; fairly large shells 90.
Beak cavity moderate; no posterior ridge; usually small shells 87.

87. Umbonal markings fine or inconspicuous; rays sometimes present on the posterior slope 88.
Umbonal markings coarse irregular bars; usually rayless 89.

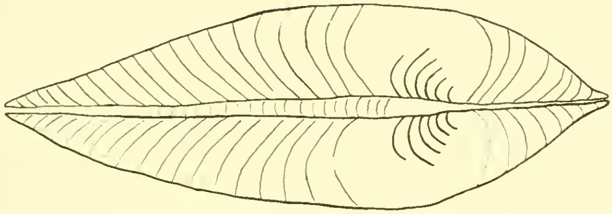
88. Posterior margin slightly winged; beak markings many fine double loops; nacre bluish-white; Mississippi drainage
Lampsilis subrostrata (Say)
Ligumia subrostrata (Say)
Posterior margin not winged; no evident beak markings; nacre often salmon to purple; central and lower Mississippi drainage
Lampsilis lienosa (Conrad) Black Bean
Micromya lienosa (Conrad)



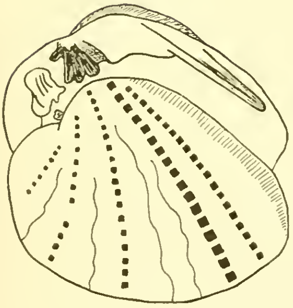
OBLIQUARIA REFLEXA



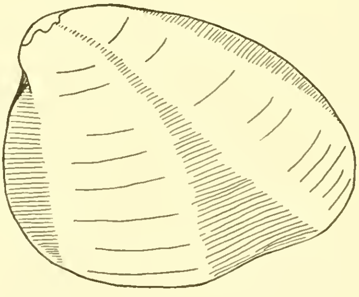
LAMPSILIS NASUTA



ELLIPTIO TETRALASMUS



PLAGIOLA LINEOLATA



QUADRULA CORDATA

89. Umbonal markings three irregular nodulous ridges; beaks full; nacre salmon to purple; usually less than one and one-half inches long; east-central states

Carunculina glans (Lea) Purple Lilliput Shell

Umbonal markings five or more sharp ridges turned up behind; beaks moderate to low; nacre white, bluish or salmon; becoming two inches long; east-central and central states

Carunculina parva (Barnes) Lilliput Shell

90. With a low posterior ridge sloping toward the postbasal angle 91.

Shell more evenly rounded or pointed behind 94.

91. Beak cavity impressed; usually with faint wavy rays; New York to North Dakota and south to Ohio

Lampsilis ellipsiformis (Conrad) Ellipse

Actinonaias ellipsiformis (Conrad)

Beak cavity shallow; rays often obscure 92.

92. No interdentum; beak markings several concentric loops drawn together and curved up behind; central states

Elliptio tetralasmus (Say)

Uniomerus tetralasmus (Say)

With an interdentum; beak markings not so 93.

93. Epidermis usually dark; nacre usually purplish; Atlantic drainage

Elliptio complanatus (Dillwyn) Spike

Epidermis usually tawny; nacre white; east-central states

Ptychobranchus fasciolare (Raf.) Kidney Shell

94. Epidermis and nacre both shining; epidermis usually brightly rayed; greatest height usually through the end of the laterals, with the shell often swollen in this region 95.

Epidermis usually rather dull; shell not higher posteriorly 97.

95. Rays usually broken; shell thin and small

Lampsilis nervosa (Raf.) Rainbow Shell

Micromya iris (Lea)

Rays often wavy; shell moderate; becoming large 96.

96. Nacre thickened anteriorly; nacre white or pink; posterior slope rounded; east-central and central states

Lampsilis fasciata (Raf.) Fat Mucket

Lampsilis siliquoidea (Barnes)

(*Lampsilis luteola* (Lamarck))

Nacre not much thickened anteriorly; nacre silvery, often bluish or brown in cavities; posterior slope slightly flattened; south-central states

Lampsilis fasciata hydiana (Lea) Southern Fat Mucket

Lampsilis hydiana (Lea)

97. Teeth small and delicate; epidermis dull, with many rays; nacre dull, often tinged with salmon or purple; valves very shallow; Atlantic drainage

Lampsilis radiata (Gmelin) Eastern Mucket

Teeth fairly solid; epidermis dull, with obscure and often faintly interrupted rays; nacre white or pink; valves only moderately shallow; Mississippi drainage

Lampsilis carinata (Barnes) Mucket
Actinonaias carinata (Barnes)

98. Epidermis with a dull, mat or satiny finish and with obscure or no rays (color markings), except in some young shells; epidermis usually dark colored in adult specimens 99.
Epidermis polished or rayed; epidermis usually, but not always, yellowish 107.

99. Cardinal teeth split up; practically no interdentum; Gulf States
Glebula suborbiculata (Lamarck)
Glebula rotundata (Lamarck)
Hinge not so 100.

100. With practically no beak cavity; nacre usually purple; Mississippi drainage
Elliptio niger (Raf.) Elephant's Ear
Elliptio crassidens (Lamarck)
Beak cavity impressed; nacre white or pink 101.

101. Shell almost circular; without a posterior ridge; east-central states
Obovaria subrotunda (Raf.) Round Nigger-head
(*Obovaria circulus* (Lea))
Shell oval or triangular; with or without a posterior ridge 102.

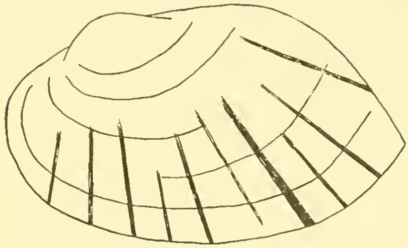
102. Shell irregularly triangular or arcuate in outline; posterior ridge moderate to strong; anterior cardinal of left valve directed to anterior half of or before the anterior muscle scar 103.
Shell ovoid; posterior ridge rounded or low; anterior cardinal of left valve directed to middle or posterior part of the anterior muscle scar 105.

103. Shell triangular, with swollen umbones; anterior cardinal of left valve directed before the anterior muscle scar; east-central and central states
Quadrula undata (Barnes) Pig-toe
Fusconaia undata (Barnes)
Shell more arcuate, with lower beaks; anterior cardinal of left valve directed to the anterior half of the anterior muscle scar 104.

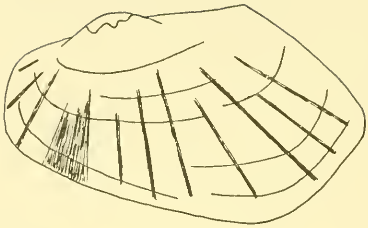
104. Hinge with a wide, heavy interdentum; shell becoming large and heavy; Ohio, Cumberland and Tennessee drainages
Quadrula subrotunda (Lea) Heavy Pig-toe
Fusconaia subrotunda (Lea)
Hinge line thinner; shell more moderate; east-central and central states
Quadrula flava (Raf.) Wabash Pig-toe
Fusconaia flava (Raf.)

105. With a low, rounded posterior ridge; nacre white or pink; anterior muscle scars seldom iridescent; east-central and central states
Quadrula coccinea (Conrad) Pink Nigger-head
Pleurobema cordatum coccineum (Conrad)
With a low, faintly double posterior ridge; nacre usually white 106.

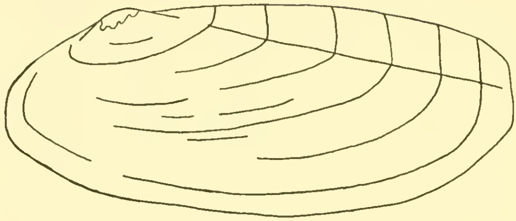
106. Base line almost straight; Virginia to North Carolina
Pleurobema subplanum (Conrad)
Lexingtonia subplanum (Conrad)
Base line curved; Tennessee drainage



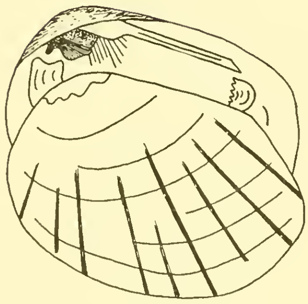
LAMPSILIS CARINATA



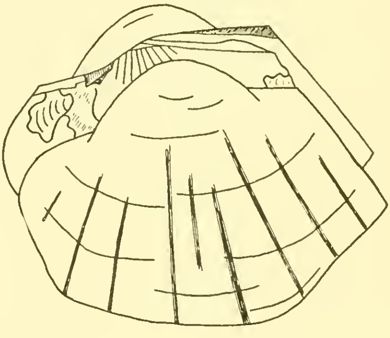
LAMPSILIS FASCIATA



LAMPSILIS RECTA



OBOVARIA OLIVARIA



LAMPSILIS CARDIUM

Quadrula argentea (Lea)
Pleurobema oviforme argenteum (Lea)

107. Shell triangular or wedge-shaped, often with many fine radial lines on a flattened posterior slope; epidermis usually semi-shining, with rays broken, spotted or wavy 108.
Shell ovate; posterior slope usually rounded and without many fine radial lines; epidermis usually polished, with rays complete, sometimes wavy 118.

108. Lateral teeth scarcely longer than the lateral-like cardinals; shell thin and usually rayless; becoming about five and one-half inches long; Ohio River drainage
Lampsilis ovata (Say) Ohio Pocketbook, Grandma
Lateral teeth distinctly longer than, and unlike, the cardinals; usually rayed and smaller 109.

109. Shell much flattened; hinge plate very heavy; epidermis yellow, with dark rays which may be broken up into square blotches; central and east-central states
Plagiola lineolata (Raf.) Butterfly Shell
Shell moderately swollen 110.

110. Posterior ridge obscure or faintly double; rays usually wavy 111.
Posterior ridge well developed 114.

111. Hinge teeth heavy; muscle scars small and round 112.
Hinge teeth moderate; muscle scars large 113.

112. Beaks small, median; rays usually wavy; Ohio River drainage
Lemiox fabalis (Lea)
Micromya fabalis (Lea)
Beaks more anterior; rays obscure; Tennessee drainage
Lemiox rimosus (Raf.)
Micromya caelatus (Conrad)

113. Nacre purplish; ventral margin almost straight; Ohio River drainage
Dysnomia sulcata (Lea) Cat's Paw
Nacre white or salmon; ventral margin outcurved; Ohio River drainage
Dysnomia personata (Say)

114. Rays obscure; shell much swollen, with the dorsal and posterior margins meeting at an angle of about 90°; Tennessee and Cumberland Rivers
Dysnomia arcaeformis (Lea) Sugar-spoon
Rays usually broken; shell full, with a sloping posterior-dorsal margin 115.

115. Posterior muscle scars very deep; posterior ridge of female toothed and much inflated; Tennessee
Dysnomia brevidens (Lea)
Posterior muscle scars shallow; posterior ridge of female not greatly expanded 116.

116. Lower half of posterior ridge rounded; lunule often very wide; central states
Truncilla donaciformis (Lea)

Posterior ridge sharp; lunule narrow; central and east-central states 117.

117. With a radial depression before the posterior ridge; with a few radial lines on a flat posterior slope

Truncilla truncata Raf. Deer-toe

No radial depression before the posterior ridge; with many fine radial lines on a flattened posterior slope

Dysnomia triquetra (Raf.)

118. Shell and hinge line thick and heavy; Mississippi River

Lampsilis higginsii (Lea) Higgin's Eye

Shell and hinge moderate to thin 119.

119. Posterior ridge very sharp and posterior slope flat, so that the shell looks as if it had been sliced off posteriorly; Ohio River drainage

Lampsilis ovata (Say) Ohio Pocketbook, Grandma

Posterior ridge moderate or absent 120.

120. Shell evenly marked with many fine wavy rays; small, seldom over three inches; Ohio River drainage

Lampsilis fasciola Raf. Wavy-lined Pocketbook

(*Ligumia fasciola* (Raf.))

(*Lampsilis multiradiata* (Lea))

Rays usually irregularly distributed and of varying widths; becoming larger 121.

121. With a moderate posterior ridge; nacre tinged with red or purple; Atlantic drainage only

Lampsilis ochracea (Say) Red-lined Pocketbook

Posterior ridge not well marked; nacre white or pinkish; Atlantic and Mississippi drainages 122.

122. Cardinals of right valve long and thin, resembling the laterals; epidermis smoky, scarcely rayed; shell thin and very much inflated; southern Mississippi drainage

Proptera capax (Green) Fat Pocketbook

Cardinals tooth-like, rather than knife-like; epidermis yellow, usually rayed 123.

123. Rays largely confined to the posterior slope; Atlantic drainage

Lampsilis cariosa (Say) Eastern Pocketbook

Rays usually scattered; Mississippi drainage

Lampsilis cardium Raf. Common Pocketbook

Lampsilis ventricosa (Barnes)

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The names of genera and species used as first choice in the section of the snail key devoted to land snails coincide with the classification in Pilsbry's *Monograph* (1939-41). The names used as first choice in the clam key are those given in Frierson's *Check List*. The unbracketed names given as second choice are accepted by many conchologists and are found in much of the literature.

ARTHROPODA

Chapter 7

The group or phylum *Arthropoda* consists of those invertebrates that have jointed appendages, and includes an immense number of diverse forms. Over three-fourths of a million species have been named and described, and about eighty-five per cent of all the known animals belong in this group. They are to be found wherever life is possible and consequently show remarkable adaptations. Practically all of them, however, possess jointed appendages, at least in the adult stages, and the body also is made up of a series of segments, usually from eighteen to twenty-three. Partial fusion often makes it difficult to distinguish all, however, especially in the head region. Typically each body segment bears a pair of appendages, but in most cases many of these appendages serve some other purpose than that of locomotion. Those on the head region have been especially modified and may even serve as jaws, so that the novice is surprised to find that the jaws of the crayfish or grasshopper work inward from each side instead of up and down like those of the vertebrates. The skin is hardened by secretions of chitin, an advantage in most respects but a decided disadvantage when growth occurs. Periodically the arthropod becomes too large for its skin, which must then be shed and replaced by one of a larger size. These cast-off skins are frequently encountered and are often perfectly complete, only a slit in the back indicating how the former occupant escaped.

The scientist divides the *Arthropoda* into several groups. One of these, the *Onychophora*, is a resident of the subtropics, but is of much theoretical interest because its members combine several typically annelid structures with other equally typical arthropod structures and thereby form a connecting link between two major groups. The other groups are generally distributed and are abundant in most parts of the United States.

Practically every stream and pond contain representatives of the *Crustacea*. This division of the *Arthropoda* is characterized by the presence of gills, usually concealed under an outgrowth of the exoskeleton, and by two pairs of antennae, in typical forms. The crayfish is our largest fresh-water example, but it is outnumbered by hosts of almost microscopic forms. Most of the *Crustacea* are essentially aquatic, while the great majority of the rest of the arthropods are land-dwelling animals or only temporary dwellers in the water.

Another large group of the *Arthropoda*, the *Arachnida*, is characterized by the lack of antennae. The majority of them have the head and thorax completely fused, so that only two body sections are apparent. The spiders, which are so often found as unwelcome invaders of our homes, belong to this group, and so do the mites, harvestmen, scorpions and their relatives.

The *Myriapoda,* commonly called centipedes and millipedes or hundred-legs and thousand-legs, make up another division of the arthropods and are common in damp, dark places on land.

The remaining division of the *Arthropoda,* the *Insecta,* has as almost its only common character the possession of six walking legs in the adult. It comprises such a gathering of almost innumerable kinds and forms that the study of them, Entomology, has attained an almost independent status, corresponding somewhat to the position that Bacteriology holds in Botany. Studies of the methods of controlling insects are now occupying much attention, for it is estimated that insects take a toll of at least one-tenth of all food crops, and occasionally heavy infestations of insects destroy entire crops over large areas. In addition to the loss of food there are many insect-carried or insect-spread diseases, such as malaria and typhoid.

ANNOTATED LIST OF THE CLASSES OF ARTHROPODA

Class CRUSTACEA

Gill-breathing; usually with two pairs of antennae

Class MYRIAPODA

With tracheae, one pair of antennae, many similar legs

Class ARACHNOIDEA

No antennae; with two main divisions, cephalothorax and abdomen

Subclass ARACHNIDA

With tracheae, book lungs or book gills

Class INSECTA (or *Hexapoda*)

With tracheae, one pair of antennae, three pairs of legs

ANNOTATED LIST OF THE SUBCLASSES AND ORDERS OF CRUSTACEA

Subclass ENTOMOSTRACA

Without abdominal appendages; small, often minute

Order BRANCHIOPODA

Thoracic appendages flat and leaf-like

Suborder PHYLLOPODA

Body distinctly segmented; with nine to forty pairs of appendages

Suborder CLADOCERA

No distinct segmentation; usually with a bivalve carapace, which may or may not completely cover the body; seldom more than six pairs of appendages

Order COPEPODA

Thoracic appendages cylindrical; body more or less elongate and usually distinctly segmented

Order OSTRACODA

Body without distinct segmentation and entirely enclosed in a bivalve carapace; with seven pairs of cylindrical appendages

Subclass MALACOSTRACA

Small or large crustaceans with appendages on abdomen

Order MYSIDACEA

With a carapace over head and thorax; walking legs all biramose

Order DECAPODA

With a carapace over head and thorax; walking legs not biramose

Suborder NATANTIA Shrimps and Prawns

Shrimp-like; pleopods aid in swimming

Suborder REPTANTIA Crayfishes

Lobster-like; pleopods do not aid in swimming

Order AMPHIPODA

Body laterally compressed; no carapace

Order ISOPODA

Body flattened dorso-ventrally; no carapace

ANNOTATED LIST OF THE ORDERS OF ARACHNIDA

Order SCORPIONIDA Scorpions

Elongate, the tail-like abdomen bearing on its end a poisonous sting

Order PALPIGRADI Microscorpions

Minute; spider-like, but with a long, tufted and segmented tail

Order PEDIPALPI Whip-scorpions

First pair of legs much elongated; with or without a long, thread-like tail

Order SOLPUGIDA Solpugids

Head distinct from thorax and with very large, pinching structures

Order CHELONETHIDA (or *Pseudoscorpionida*) False Scorpions

Tiny, flattened forms, with relatively huge chelae

Order PHALANGIIDA Harvestmen or Daddy-long-legs

Body ovoid; legs very long and slender

Order ARANEIDA (or *Araneae*) True Spiders

Thorax and head completely fused, and distinct from the abdomen

Order ACARINA Mites

Body ovoid, cephalothorax and abdomen not distinct; legs short

Order TARDIGRADA Water Bears

Minute, usually aquatic; body and legs unsegmented

ANNOTATED LIST OF THE ORDERS OF MYRIAPODA

Order PAUROPODA

Minute animals with three-branched antennae

Order SYMPHYLA

Minute animals with unbranched antennae

Order DIPLOPODA Millipedes

Usually elongate-cylindrical, with two pairs of legs on most segments

Order CHILOPODA Centipedes

Elongate, flattened animals, with one pair of legs on most segments

ANNOTATED LIST OF THE PRINCIPAL ORDERS OF INSECTA

Order THYSANURA Bristle-tails and Silver-fish

Small, terrestrial, wingless insects; antennae long; with three, hair-like terminal appendages

Order COLLEMBOLA Spring-tails

Small, wingless insects; with moderately long antennae; with abdominal leaping appendage

Order ORTHOPTERA Grasshoppers and Crickets

Small to large insects; fore wings straight, narrow and stiff (Cockroaches, Mantes and Walking-sticks are usually included here, but are regarded by some entomologists as forming three separate orders, the *Blattariae,* the *Mantodea,* and the *Phasmatodea.*)

Order DERMAPTERA Earwigs

Small to moderate insects; fore wings hardened, hind wings membranous, folded under fore wings when at rest; abdomen ending in a pair of prominent forceps

Order THYSANOPTERA Thrips

Very small insects; with four narrow wings fringed with long bristles

Order ISOPTERA Termites

Colonial, polymorphic insects, somewhat ant-like, but with thorax broadly connected to abdomen

Order CORRODENTIA Book-lice, Bark-lice

Small, soft-bodied insects; wings, when present, relatively large

Order MALLOPHAGA Bird Lice

Small, wingless, external parasites of birds; body broad and flat; legs short; with biting mouth parts

Order SIPHUNCULATA (or *Anoplura*) True Lice

Small, wingless, external parasites of mammals; body flattened; with sucking mouth parts

Order HOMOPTERA Cicadas, Leaf-hoppers, Aphids

Small to moderate sized insects; with sucking mouth parts; wings not with basal part hardened

Order HETEROPTERA (or *Hemiptera*) True Bugs

Small to large insects; with sucking mouth parts; basal portion of fore wing thickened, distal part membranous

Order ODONATA Dragon-flies, Damsel-flies

Large insects; abdomen elongate; wings not folded, all membranous; head freely movable

Order EPHEMERIDA (or *Plectoptera*) May-flies

Medium sized insects; head not freely movable; fore wings much larger than hind ones

Order PLECOPTERA Stone-flies

Moderate sized insects; hind wings larger than fore wings and folded when at rest

Order NEUROPTERA Lace-wings, Ant-lions, Dobson-flies

Small to large insects; wings similar in size; predatory insects with large eyes

Order MECOPTERA Scorpion-flies

Small to medium sized insects; head prolonged into a down-curved beak bearing chewing mouth parts; four wings alike, long and narrow; legs long and slender

Order TRICHOPTERA Caddis-flies

Small to medium sized insects; wings membranous, hairy

Order LEPIDOPTERA Butterflies, Moths

Small to large insects; wings with shingle-like scales; with sucking mouth parts

Order DIPTERA Flies

Small to medium sized insects; with one pair of wings, the second pair represented by knobbed structures called halteres; with sucking, piercing or lapping mouth parts

Order SIPHONAPTERA Fleas

Small, wingless, jumping insects with piercing and sucking mouth parts; body with bristles; antennae short; legs large and stout

Order COLEOPTERA Beetles

Minute to large insects; fore wings hardened, forming a cover for the folded, membranous hind wings; with biting mouth parts

Order HYMENOPTERA Bees, Wasps, Ants

Small to medium sized insects; wings, when present, membranous, the fore wings larger; ovipositor usually sting-like

KEY TO THE CLASSES OF ARTHROPODA

1. Animal enclosed in a clam-like shell
   Crustacea
   Not so — 2.

2. With no apparent antennae — 3.
   With one or two pairs of antennae — 6.

3. Body almost cylindrical and divided into ring-like segments; with three pairs of segmented legs anteriorly or without legs — 4.
   Body more spherical, or with four or more pairs of segmented legs — 5.

4. With three pairs of segmented legs anteriorly and with three pairs of undeveloped legs on the abdomen in the adult; rare (grouped independently or with the *Insecta* or with the *Arachnida* by various writers)
   Myrientomata, (Order *Protura*)
   Larval forms; with or without legs
   Insecta or *Hexapoda* Insects

5. With many pairs of body appendages
   Crustacea
   With four pairs of legs
   Arachnoidea, Subclass *Arachnida* Arachnids

6. With two pairs of antennae
   Crustacea
   With one pair of antennae — 7.

7. With three pairs of segmented legs; usually, but not always, with wings in the adult
   Insecta or *Hexapoda* Insects
   With more than three pairs of segmented legs; no wings — 8.

8. Body long and narrow, with regular segments most of which bear one or two pairs of legs
   Myriapoda Myriapods
   Body divided into thoracic and abdominal regions; appendages often irregular in size, shape or distribution
   Crustacea

CRUSTACEA

The *Crustacea* constitute one large class of the great phylum Arthropoda. They are usually distinguished from the other arthropods by the presence of two pairs of antennae. Most of them breathe by means of gills and almost all of them are aquatic. The class is divided by many writers into two sections, the *Malacostraca* and the *Entomostraca,* the former usually being relatively large animals with appendages on the abdominal segments, while the latter are usually small and have no abdominal appendages.

The term *Entomostraca* means creatures with insect-like shells or bodies and was applied by O. F. Müller in 1785. Before that time they had been very little studied, largely because of their small size and the fact that microscopic study is usually necessary in order to determine specific differences. Authorities do not agree as to the division of the *Entomostraca* into orders and suborders. A common division makes three orders of the fresh-water forms: the *Branchiopoda* or leaf-footed; the *Ostracoda*, with cylindrical appendages and bivalve shells; and the *Copepoda*, which have cylindrical appendages and no shell-like coverings.

The *Branchiopoda* or leaf-footed *Crustacea* are further divided into two groups, one of which is characterized by an elongate, distinctly segmented body and the other by a short, indistinctly segmented body, usually partly covered by an apparently bivalve shell. The best known and most common members of the first group or *Phyllopoda* are the fairy shrimps, which sometimes appear in huge numbers in temporary ponds in early spring and disappear within a few weeks or even days. These dainty creatures, like most of the *Phyllopoda*, swim on their backs. The males have the second pair of antennae much enlarged to serve as clasping organs in mating. A study of these modified antennae is usually necessary in order to identify genera and species. The females are usually burdened with large sacs of eggs. These eggs soon fall to the bottom of the pond and are able to endure both desiccation and freezing before they hatch. Indeed it is reported that the eggs of some species will not hatch until such strenuous conditions have been met. The frequent abundance of fairy shrimps in small temporary ponds and their rarity in or absence from larger, more permanent ponds support this idea.

The other suborder of *Branchiopoda*, the *Cladocera*, were observed by the naturalist Swammerdam in 1669, when the microscope was in its infancy. He called them "water fleas", a name which has since been incorporated into the scientific name of one of the most common forms, *Daphnia pulex*. In recent years the importance of these tiny *Crustacea* as food for small fish has been discovered, and the species of the genus *Daphnia* and other genera have been widely collected and grown in cultures as food for aquarium fishes. They are excellent subjects for examination under the low power of the microscope, for they are usually so transparent that the internal organs are easily seen. One striking feature is the brood case or space between the top of the body and the shell. Here the eggs undergo their development, so that often several well-developed young, miniatures of the parent, may be seen. During most of the year eggs are formed and develop without fertilization. As a matter of fact males are rare and in some species have never been observed. Sexual reproduction appears to occur only when living conditions become unfavorable, and then only one or two eggs are produced, the shell of the parent becoming thickened and modified and being shed with the egg or eggs still in it. The eggs then lie dormant until the next favorable season arrives.

The *Ostracoda* have bivalve shells that cover the whole animal and the legs are cylindrical rather than flattened. When inactive they look like tiny clams, but in action the shell opens and the appendages flash out and perform their task of propulsion most efficiently. Like the *Cladocera*, the *Ostracoda* are abundant in most bodies of fresh water and play an important part as food for young fishes.

The fresh-water *Copepoda* are mostly free-living, but a few are serious parasites upon fish. One of these parasitic forms, *Argulus*, is commonly called the carp louse, but it is also common upon goldfish and some others. Its body is much modified and resembles a fish scale. It can swim well, but spends much of its time crawling upon or hanging in the gill chamber of fish, sucking the blood of its host. The other forms of parasitic *Copepoda* are, in the female, even more modified in body form and are incapable of swimming, as their legs are rudimentary. The mouth appendages are modified into sucking or clasping organs. Their bodies are worm-like or sac-like. Two long sacs of eggs often hang from the rear. The free-living *Copepoda* are well represented by the common genus *Cyclops*, so named because of the single red eye in the center of its head. It has a pear-shaped body ending in a long tail, and a pair of large egg sacs are usually towed by the female.

The *Entomostraca* are easily collected by means of a plankton net. Many of them will thrive and multiply in an aquarium, provided no small fish or hydra are present to devour them. Some magnification is necessary in order that their distinctive characters may be determined. If the animal is too active in a water mount under the microscope, a weak solution of glycerine may be used as a mounting medium to retard motion. The collector is often puzzled by a great variety of forms, which on close study may turn out to be immature stages of a few common forms. A young phyllopod or copepod usually hatches from the egg as a flat, oval body with three pairs of appendages, a state called the *nauplius* stage. As it grows a series of moults occurs, each one bringing it nearer to the adult condition in regard to the number of segments and development of appendages. Most of the parasitic copepods omit the earlier stages, hatching in forms much resembling *Cyclops* and then going through a process of degeneration.

The *Malacostraca* or soft-shelled animals were so called by Aristotle, who used the term to separate them from the *Mollusca* or hard-shelled animals. Three groups are common in fresh water, and a fourth is represented by one fresh-water species, *Mysis relicta*, which is found in the Great Lakes. The name "relicta" was given to it because it was assumed to be a "marine relic", which implied that the great lakes of Europe and America in which it occurs had once been inland seas or inlets from the ocean. The other groups are the *Decapoda*, including the crayfish, shrimps and prawns; the *Amphipoda* or scuds; and the *Isopoda*.

The latter group has some members that have started to develop a tracheal system for air-breathing and so have become able to leave the water and dwell in moist places on land. They are often common in damp cellars and under boards or rocks in yards and gardens. Some of them can roll into a ball, when disturbed, and have received the name of pillbugs. The others are commonly called sowbugs or wood-lice. All are flattened dorso-ventrally, the aquatic *Isopoda* extremely so. These usually hide in and feed upon water plants and themselves are eagerly sought and eaten by fishes. Unlike the other groups of *Malacostraca* the *Isopoda* have no thoracic gills, but instead have the abdominal appendages especially modified to serve this function.

The *Amphipoda* are also flattened, but in the other dimension, so that they appear to have been designed to slip between the stems of water plants. The female amphipod (like the *Isopoda*) carries its eggs in a brood pouch formed by outgrowths from the thoracic appendages. The amphipods also make good food for young fishes.

The *Decapoda* are the largest and most conspicuous of the fresh-water *Crustacea*. The crayfishes look much like miniature lobsters except that their chelae or large pinchers are alike. They are frequently miscalled crabs, but the crabs have very small abdomens carried tucked under the rounded cephalothorax and are to be found only along the coasts. The common name of crayfish is probably derived from the more descriptive term of "crevice-fish". They can retreat from danger with the greatest speed by flipping backwards, so that to "crawfish out" of a situation has become a common phrase in our language.

Crayfishes are of much interest ecologically, since the various species show markedly differing preferences as to habitat, some living only in large streams, some only in still ponds, and some forsaking even these to live in muddy burrows often topped by five or six inch chimneys of excavated material. As much diversity is shown in reproduction, some species mating only in the autumn to produce young the next spring and some species apparently mating freely at any time of the year. Even the body color varies with the locality and the normal dull brown may be replaced by a decided blue or red.

The identification of crayfish is complicated because the main distinguishing characters must be based on the sexual differences of the mature males. The sexually potent males, with horny tips on the first pair of abdominal appendages and with well developed copulatory hooks on the third segments of the second, third or fourth pair of legs, are said to be in the first form. In most crayfishes this form occurs in the autumn and winter, when copulation takes place. In spring and summer male crayfishes are in the second form, usually sexually impotent and with their sexual characters suppressed.

The eggs are carried by the female on her abdominal appendages or swimmerettes, which she continually waves to aerate the eggs. She checks them over carefully and promptly discards any that fail to develop properly. Unlike the lobster and many other crustaceans, the crayfish does not go through a series of developmental stages that may recapitulate the evolutionary history, but starts its free life as a miniature of its parent.

Crayfishes make interesting aquarium pets. Those from ponds or slowly moving water naturally live better under aquarium conditions than those from swift streams. For best results the container should be arranged so that the crayfish may emerge from the water when it so desires. As a matter of fact many crayfishes spend a good deal of the night at the very edge of the water or out on the mud flats. The raccoons know this and profit by it. As long as the gills remain moist the crayfish can survive, and most fishermen have learned to carry their bait crayfish in damp moss rather than in water. At the time of the shedding of the skin, which splits across the back and enables its occupant to "jack-knife" out, a captive crayfish should be removed from its fellows, so that they cannot profit by its helplessness to make a meal of it.

Crayfish are omnivorous and all is grist that comes to their mill, be it dead or alive, plant or animal. Undoubtedly they play an important part in the economy of nature, cleaning up all waste and becoming in their turn food for other animals.

KEY TO THE ORDERS OF CRUSTACEA

1. Small or microscopic animals; body without appendages on the abdomen or enclosed within a bivalve or apparently bivalve shell — Subclass *Entomostraca* 2.
   Large or small but not usually microscopic; with legs or modified appendages on the thorax and the abdomen; no bivalve shell — Subclass *Malacostraca* 5.
2. No bivalve shell; with cylindrical, two-branched thoracic appendages (or much modified in parasitic forms)
   Copepoda Copepods
   With an actual or apparent bivalve shell or with flattened or simple thoracic appendages 3.
3. With a bivalve shell enclosing the animal, resembling a tiny clam; less than four pairs of body appendages
   Ostracoda Ostracods
   No clam-like shell—or, if so, with five or more pairs of body appendages 4.
4. With five or six pairs of body appendages; body indistinctly segmented
   Branchiopoda, Suborder *Cladocera* Water Fleas
   With eight or more pairs of body appendages; body distinctly segmented
   Branchiopoda, Suborder *Phyllopoda* Phyllopods or Fairy Shrimps
5. No carapace or shell 6.
   With a carapace 7.

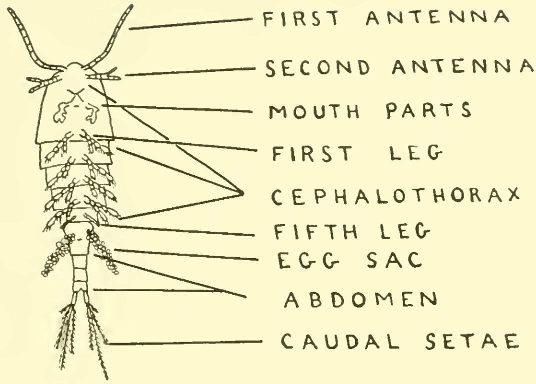

DIAGRAM OF A FEMALE COPEPOD - VENTRAL VIEW

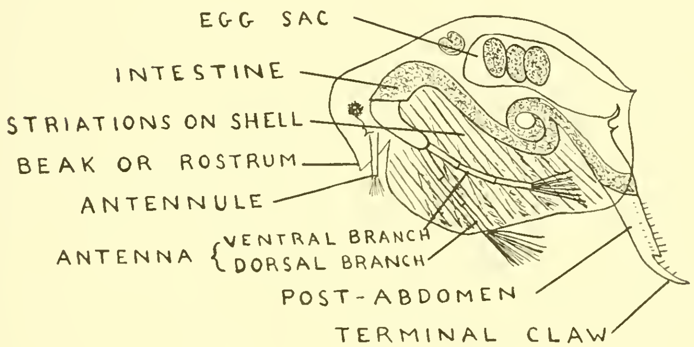

DIAGRAM OF A FEMALE CLADOCERAN - SIDE VIEW

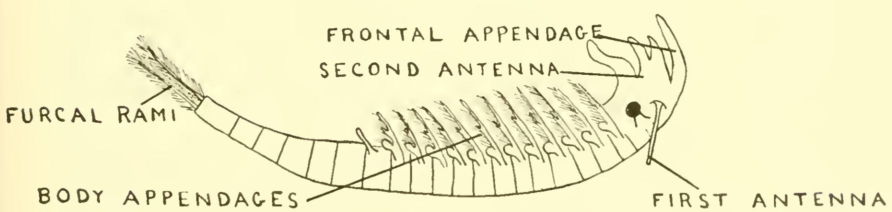

DIAGRAM OF A MALE PHYLLOPOD - SIDE VIEW

6. Body flattened sideways; some of the body appendages much different from the others; often jumping animals
Amphipoda Amphipods or Scuds
Body flattened dorso-ventrally; legs (except first and last) practically alike; rarely jumping
Isopoda Isopods, Sowbugs or Pillbugs

7. Carapace joined to three or less thoracic segments; all of the thoracic appendages two-branched; eggs carried in an egg sac at the base of the peraeopods of the female
Mysidacea, Mysis relicta Loven Opossum Shrimp
Carapace joined to all of the thoracic segments; most or all of the thoracic appendages single (do not consider opposing claws on ends as branches); eggs attached to the pleopods
Decapods Crayfishes, Shrimps and Prawns

KEY TO THE PRINCIPAL GENERA OF PHYLLOPODS OR FAIRY SHRIMPS

1. With a shell or carapace 2.
No shell or carapace—*Anostraca* 9.

2. Shell in one piece; flattened dorso-ventrally, and covering only the anterior part of the body—*Notostraca* 3.
Shell bivalve, flattened laterally, and enclosing the animal—*Conchostraca* 4.

3. With only two slender processes projecting from the end of the abdomen
Apus Schaeffer (of Family *Apodidae*)
With a central paddle-shaped appendage between the two slender processes projecting from the end of the abdomen
Lepidurus Leach (of Family *Apodidae*)

4. No concentric growth lines on the shell; Family *Lynceidae*
Lynceus Müller
(*Limnetis* Loven)
With concentric growth lines on the shell 5.

5. With less than six concentric growth lines on the shell
Eulimnadia Packard (of Family *Limnadiidae*)
With more than fifteen concentric growth lines on the shell 6.

6. With a frontal appendage on the head; shell covering head; Atlantic states
Limnadia Brongniart (of Family *Limnadiidae*)
No frontal appendage (process between the antennae) 7.

7. With a spine on the rostrum (Family *Leptestheriidae*)
Leptestheria Sars
(*Estheria* Rüppell (part))
No spine on the rostrum; Family *Caenestheriidae* 8.

8. With fourteen or fifteen segments in the flagellum of the second antenna
Caenestheriella Daday
(*Estheria* Rüppell (part))

With sixteen or seventeen segments in the flagellum of the second antenna
Cyzicus Adouin
(*Estheria* Rüppell (part))

9. Second (large) antennae of males three-jointed
Streptocephalus Baird (of Family *Streptocephalidae*)
Second antennae of males two-jointed 10.

10. Males without processes between the antennae (frontal appendages); Family *Branchinectidae* 11.
With frontal appendages between antennae of males or with a flattened process from the inner side of the base of each second antenna of males; Family *Chirocephalidae* 12.

11. With eight segments to apparent abdominal region; found in salt lakes or salt evaporating basins
Artemia Leach
With nine segments to apparent abdominal region; fresh-water animals
Branchinecta Verrill

12. Most of abdominal segments fused together
Thamnocephalus Packard
Abdomen completely segmented 13.

13. Male frontal appendages long and irregularly twisted together
Branchinella Sayce
Male frontal appendages short or more regularly coiled 14.

14. Male frontal appendages long and closely coiled
Pristicephalus Daday
(*Eubranchipus* Verrill (part))
Male frontal appendages shorter
Eubranchipus Verrill

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Packard, A. S. 1883. A Monograph of the Phyllopod Crustacea of North America, etc. 12 Ann. Rept. U. S. Geol. Surv.

Pearse, A. S. 1918. The Fairy Shrimps (Phyllopoda) Chap. 21 in Ward and Whipple's "Fresh-water Biology". John Wiley & Sons. New York.

KEY TO THE PRINCIPAL GENERA OF CLADOCERA OR WATER FLEAS

1. Body not enclosed in a shell (shell covering only the egg case) 2.
Body enclosed in a shell (head usually protruding outside) 3.

2. With four pairs of flattened feet; Family *Polyphemidae*
Polyphemus O. F. Müller
With six pairs of cylindrical feet; Family *Leptodoridae*
Leptodora Lilljeborg

3. Antennae of the female with only one branch; entire animal, including the shell, enclosed in a bivalve, transparent case; Family *Holopedidae*
Holopedium Zaddach
Not so 4.

4. Intestine only slightly curved 5.
Intestine with one or more coils 18.

5. Dorsal branch of antennae with two segments; Family *Sididae* 6.
Dorsal branch of antennae with three or four segments 9.

6. With a beak 7.
No beak 8.

7. Eye dorsal
Latona Straus
Eye ventral
Pseudosida Herrick

8. Eye ventral
Diaphanosoma Fischer
Eye dorsal
Latonopsis Sars

9. Antennules small in the female, scarcely descending below the tip of the head 10.
Antennules large in the female 14.

10. Body with a long slender projection from the middle of the posterior end
Daphnia O. F. Müller (of Family *Daphnidae*)
Body flattened, rounded or slightly pointed on posterior; a spine may project from the junction of the posterior and ventral margins 11.

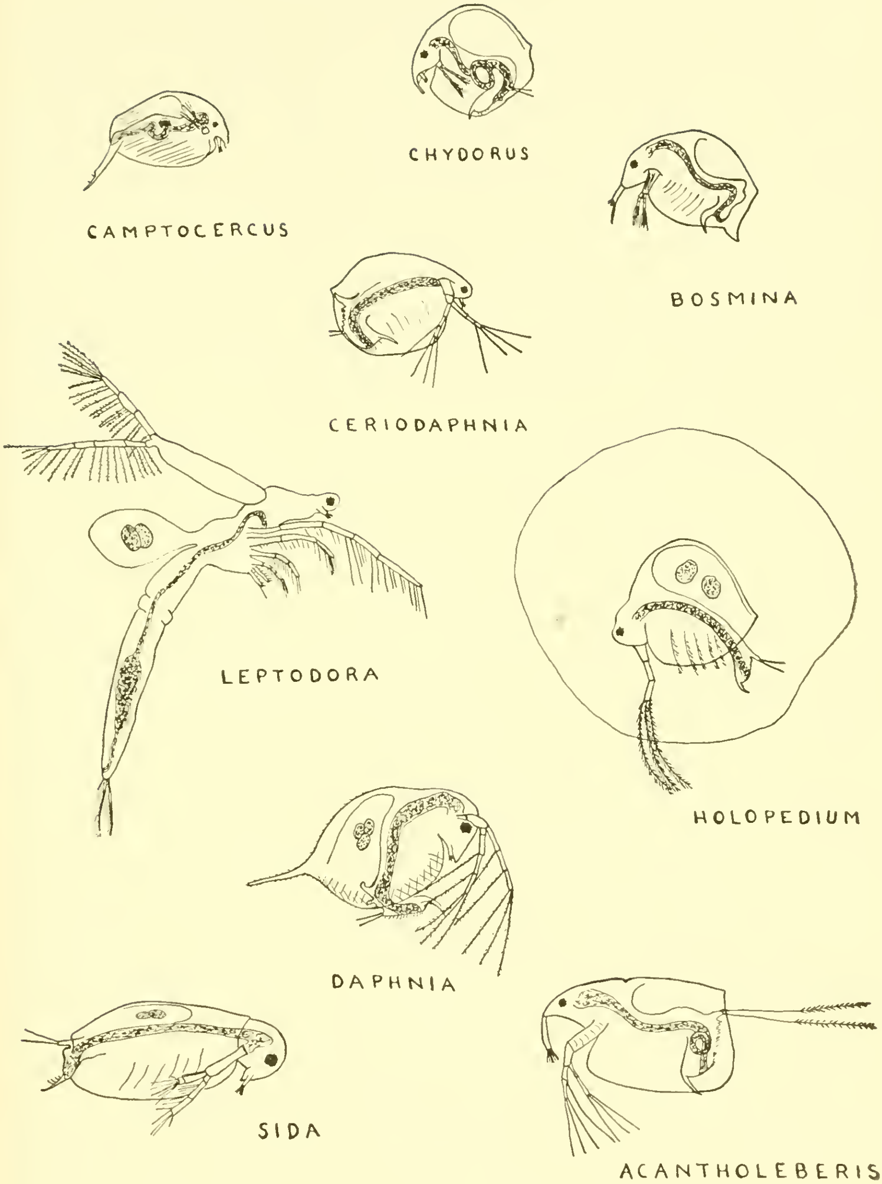
11. No beak in the female; usually rounded posteriorly
Ceriodaphnia Dana (of Family *Daphnidae*)
With a beak in the female; usually flattened or slightly pointed posteriorly 12.

12. Dorsal branch of antennae with three segments, ventral branch with two segments
Sida Straus (of Family *Sididae*)
Dorsal branch of antennae with four segments, ventral branch with three segments; Family *Daphnidae* (part) 13.

13. Shell noticeably striated; posterior margin flattened and pointed above
Simocephalus Schoedler
Shell scarcely striated; with a spine projecting backwards from the junction of the posterior and ventral margins
Scapholeberis Schoedler

14. Antennules projecting from the lower side of the head behind the eye 15.
Antennules projecting from the tip of the head before the eye 16.

15. General shape triangular, with a flattened posterior margin meeting the dorsal margin at an angle
Ilyocryptus Sars (of Family *Macrothricidae*)
Posterior margin rounded or pointed
Moina Baird (of Family *Daphnidae*)



CLADOCERA (MAGNIFIED)

16. Antennules immovable in female; end of body flattened, with a spine projecting backwards from junction of posterior and ventral margins; Family *Bosminidae*
Bosmina Baird
Antennules movable in female; posterior margin usually rounded or pointed at top or middle; Family *Macrothricidae* (part) 17.

17. Most of setae on antennae almost smooth or with a few spines or processes
Macrothrix Baird
Setae feathery
Lathonura Lilljeborg

18. With long movable antennules projecting from tip of head; Family *Macrothricidae* (part) 19.
Antennules usually short, projecting from behind a very pronounced beak; Family *Chydoridae* 23.

19. Coil of intestine in posterior end of body, partly in the post-abdomen 20.
Coil of intestine in about the middle of the body 21.

20. With a flattened posterior margin
Acantholeberis Lilljeborg
With a rounded or pointed posterior margin
Streblocerus Sars

21. Posterior margin rounded; dorsal margin with a backwards projection in about the middle
Drepanothrix Sars
Posterior margin rounded or tube-like; dorsal margin even 22.

22. Upper part of posterior margin pointed
Ophryoxus Sars
Posterior margin drawn out into a short tube
Parophryoxus Doolittle

23. Intestine ending at the end of the post-abdomen
Eurycercus Baird
Intestine ending well up on the post-abdomen 24.

24. Rostrum not projecting downwards beyond antennules; each of two claws on post-abdomen with one or no spines 25.
Rostrum distinctly longer, or else claw on post-abdomen with two or more spines, or both 30.

25. Post-abdomen large, wide, and with numerous large spines
Leydigia Kurz
Post-abdomen narrow or with short spines 26.

26. Anterior margin of head and beak very slightly incurved or almost straight
Graptoleberis Sars
Anterior margin of head and beak curving outwards 27.

27. Post-abdomen bent abruptly outwards and about twice as wide below end of intestine
Dunhevedia King
Post-abdomen not abruptly much wider below end of intestine 28.

28. Post-abdomen long and narrow with nearly parallel sides and with spines along the side getting larger at the end and about one-half the size of the terminal claw

Oxyurella Dybowski & Grochowski
(*Odontalona* Birge)

Post-abdomen usually broad; with small spines of about equal size along the side 29.

29. Spines along the edge of post-abdomen usually smaller than the row just back from the edge, if these are present

Alonella Sars

Spines along edge of post-abdomen usually larger than the row back from the edge, about one-half or more the size of the spine at the base of the terminal claw

Alona Baird (part)

30. With a spine about the size of the basal spine of the terminal claw projecting from the middle of the terminal claw on the post-abdomen 31.

Not so 35.

31. Rostrum very narrow and somewhat longer than antennules (not counting setae of antennules)

Kurzia Dybowski & Grochowski
(*Pseudalona* Sars)
(*Alonopsis* of some writers)

Rostrum thick, about length of antennules 32.

32. With a row of spines back from the edge of post-abdomen but no row along the edge

Acroperus Baird

With a row of spines along edge of post-abdomen, with or without a row back from the edge 33.

33. Valves faintly marked with concentric lines; head small, with rostrum not descending half way down height of body

Euryalona Sars

Valves marked with lengthwise or oblique parallel lines; head large, with rostrum descending below mid-line of height of body 34.

34. With a dorsal crest; post-abdomen slender

Camptocercus Baird

No dorsal crest; post-abdomen moderate to broad

Alonopsis Sars

35. Body almost round

Chydorus Leach

Body long oval or rectangular 36.

36. With one spine at base of terminal claw on post-abdomen

Rhynchotalona Norman

With two spines or with one spine and a bunch of spicules at base of terminal claw on post-abdomen 37.

37. With one spine and a bunch of spicules at base of terminal claw

Alona Baird (part)

With two spines at base of terminal claw

Pleuroxus Baird

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Birge, E. A. 1918. The Water Fleas (Cladocera). Chap. 22 in Ward and Whipple's "Fresh-water Biology". John Wiley & Sons. New York

Herrick, C. L. and Turner, C. H. 1895. Synopsis of the Entomostraca of Minnesota. Second Report of the State Zoologist. Geol. & Nat. Hist. Surv. of Minn.

KEY TO SOME OF THE MORE COMMON GENERA OF OSTRACODS

1. Last pair of legs directed downwards and used in moving about 2.
   Last pair of legs directed backward and not used in moving about Family *Cypridae* 4.
2. With two pairs of legs; Family *Darwinulidae*
   Darwinula Brady & Robertson
   With three pairs of legs; Family *Cytheridae* 3.
3. Shell smooth and thin; parasitic on gills of Crustacea
   Entocythere Marshall
   Shell rough; not parasitic
   Limnocythere Brady
4. Second antennae with spines and claws at tips but no swimming setae; non-swimming animals
   Candona Baird
   Second antennae with swimming setae and terminal spines and claws; swimming animals 5.
5. Second leg ending in three tips, one or two of which are bent back towards the base of the leg
   Cypria Zenker
   Second leg ending in one or more short curved projections resembling a beak and one long spine or claw directed ahead away from the leg 6.
6. Caudal ramus with one long slender tip, besides the short basal spine
   Cypridopsis Brady
   Caudal ramus with terminal claws or setae or both 7.
7. Swimming setae on second antennae as long as the terminal spines and claws
   Eucypris Vavra
   (*Cypris* Müller)
   Swimming setae shorter
   Chlamydotheca Saussure

GENERAL REFERENCES

Herrick, C. L. and Turner, C. H. 1895. Synopsis of the Entomostraca of Minnesota. Second Report of the State Zoologist. Geol. & Nat. Hist. Surv. of Minn.

Hoff, C. C., 1942. The Ostracods of Illinois. Ill Biol. Monog. 19, Nos. 1 and 2.

Sharpe, R. W. 1918. The Ostracoda. Chap. 24 in Ward and Whipple's "Fresh-water Biology". John Wiley & Sons. New York.

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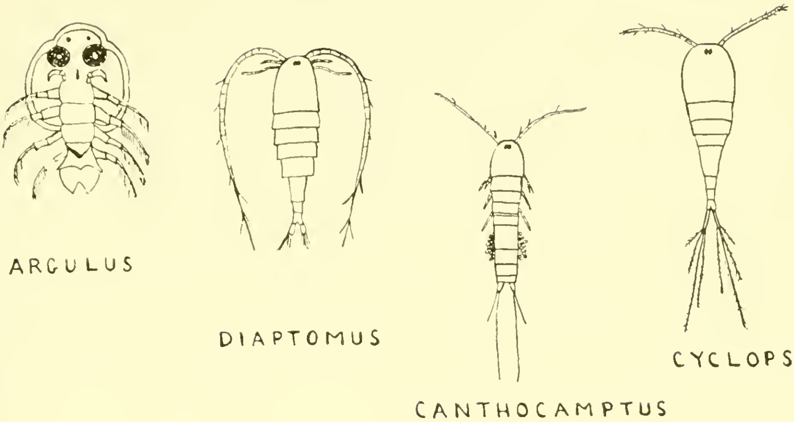
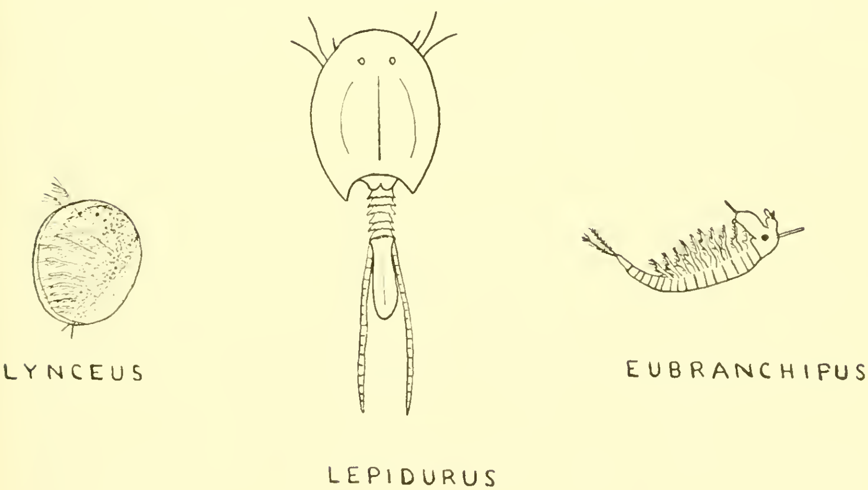


COPEPODS (MAGNIFIED)

OSTRACODS (MAGNIFIED)



PHYLLOPODS (ENLARGED)

KEY TO THE COMMON GENERA OF COPEPODS

1. Parasitic, usually on the gills of fish; mouth appendages adapted for sucking; body segments often reduced 2.
   Free-swimming; mouth appendages adapted for chewing; with five or six segments in the cephalothorax and three to five segments in the abdomen 5.

2. Body flattened, covered with a disc-shaped or oval carapace; no egg sacs; with a pair of compound eyes; Family *Argulidae*
   Argulus Müller
   Body usually more cylindrical or sac-like; females with egg sacs 3.

3. Body resembling the free swimming Copepods; Family *Ergasilidae*
   Ergasilus Nordmann
   Body more worm-like or sac-like, more or less unsegmented or with the legs minute or absent 4.

4. Usually with about four pairs of minute swimming legs; Family *Lernaeidae*
   Lernaea Linn.
   With one or two pairs of minute legs or legs absent; Family *Lernaeopodidae*
   Salmincola Wilson
   (*Lernaeopoda* Nordmann (part))

5. First antennae about as long as the body, of twenty or more segments 6.
   First antennae not longer than the cephalothorax, of eighteen or less segments 9.

6. Endopodite (inner branch) of first pair of feet of only one segment; Family *Temoridae*
   Epischura Forbes
   Endopodite of first pair of feet of two or three segments 7.

7. Endopodite of first pair of feet of two segments; Family *Diaptomidae*
   Diaptomus Westwood
   Endopodite of first pair of feet of three segments; Family *Centropagidae* 8.

8. With twenty-three or twenty-four segments in antennae
   Osphranticum Forbes
   With twenty-five segments in antennae
   Limnocalanus Sars

9. With seven or eight segments in first antennae; cephalothorax and abdomen about the same width; Family *Canthocamptidae* 10.
   With ten to seventeen segments in first antennae; abdomen distinctly and suddenly narrower than the cephalothorax; Family *Cyclopidae* 11.

10. With two segments in the small branch of the second antenna
    Canthocamptus Westwood
    With one segment in the small branch of the second antenna
    Attheyella Brady

11. With ten to twelve segments in the first antennae 12.
    With seventeen segments in the first antennae 13.

12. With ten or eleven segments in first antennae
Ectocyclops Brady
With twelve segments in the first antennae
Eucyclops Claus

13. With two plumes from the end of the fifth leg
Mesocyclops Sars
With one plume and one or two spines from the end of the fifth leg 14.

14. With one plume and one spine from the end of the fifth leg
Cyclops Müller
With one plume and two spines from the end of the fifth leg
Macrocyclops Claus

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Forbes, E. B. 1897. A Contribution to a Knowledge of North American Fresh-water Cyclopidae. Bull. Ill. Lab. Nat. Hist., Vol. 5.

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Wilson, C. B. 1903. North American Parasitic Copepods of the Family Argulidae. Proc. U. S. Nat. Museum, Vol. 25.

Wilson, C. B. 1911. North American Parasitic Copepods Belonging to the Family Ergasilidae. Proc. U. S. Nat. Museum, Vol. 39.

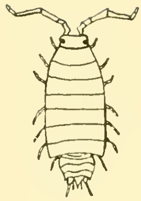
KEY TO THE COMMON GENERA OF AMPHIPODS OR SCUDS

1. Last pair of peraeopods (legs on thorax) shorter than the preceding pair; Family *Lysianassidae*
Pontoporeia Kroyer
Last pair of peraeopods longer than the preceding pair 2.

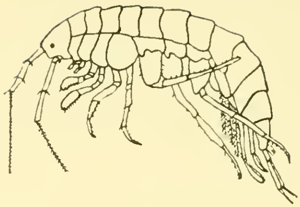
2. Telson not split 3.
Telson (central posterior appendage) partly or wholly split lengthwise Family *Gammaridae* 4.

3. First pair of antennae without any small branch portion; with functional eyes; in rivers, ponds etc.; Family *Talitridae*
Hyalella Smith
First pair of antennae with one very short branch from middle or from near end; blind; in caves or wells
Crangonyx Bate (of Family *Gammaridae*)

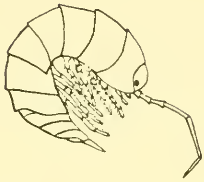
4. Telson almost wholly or completely split
Gammarus Fabricius
Telson split not more than three-quarters of its length 5.



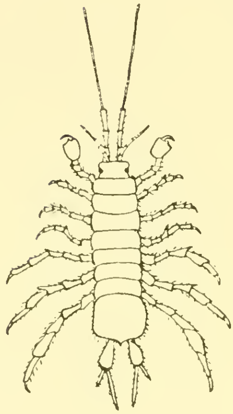
PORCELLIONIDES



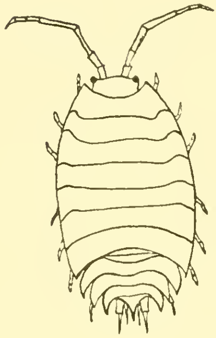
GAMMARUS



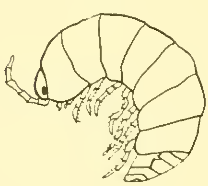
CYLISTICUS



ASELLUS



ONISCUS



ARMADILLIDIUM

AMPHIPODS AND ISOPODS

5. Outer division of third uropods (last of three pairs of tail appendages lateral to the telson) with two segments; blind; in caves of Tenn.
   Niphargus Hay
   Outer division of third uropods with one segment; blind or not; more generally distributed
   Eucrangonyx Stebbing

GENERAL REFERENCES

Holmes, S. J. 1903. Synopses of North American Invertebrates—The Amphipoda. Amer. Nat., Vol. 37.

Ortmann, A. E. 1918. Higher Crustaceans (Malacostraca). Chap. 25 in Ward and Whipple's "Fresh-water Biology". John Wiley & Sons. New York.

Weckel, A. L. 1907. The Fresh-water Amphipoda of North America. Proc. U. S. Nat. Museum, Vol. 32.

KEY TO THE COMMON GENERA OF ISOPODS, SOWBUGS OR PILLBUGS

1. Both pairs of antennae undeveloped; parasitic on gills of *Crustacea;* Family *Bopyridae*
   Probopyrus Giard & Bonnier
   With one or two pairs of developed antennae; not parasitic 2.
2. Both pairs of antennae apparent (more than three-jointed); water forms 3.
   First pair of antennae obscure (not more than three-jointed); usually but not always land forms 7.
3. Uropods lateral; Family *Sphaeromidae* 4.
   Uropods terminal; Family *Asellidae* 5.
4. Outer side of outer branch of uropod serrate
   Sphaeroma Latreille
   Outer side of outer branch of uropod smooth
   Exosphaeroma Stebbing
5. Head as wide as and longer than first segment of thorax; no eyes; in caves and wells
   Caecidotea Packard
   Head narrower or shorter; with eyes 6.
6. Legs (except first pair) with one claw
   Asellus Geoffroy St.-Hillaire
   Legs (except first pair) with two claws
   Mancasellus Harger
7. Uropods modified to form a flattened opercular covering for the ventral rear of abdomen; Family *Tylidae*
   Tylos Latreille
   Uropods each with two branches projecting backwards 8.

8. Uropods with two slender branches extending well posterior to the body and with the inner branch a little longer than the outer branch; Family *Ligiidae*

Ligidium Brandt

Uropods not so—either extending scarcely behind the body or with the outer branch a little longer than the inner branch 9.

9. Uropods not extending backwards beyond the rear projections of the last segment of the abdomen; animal can roll itself into a ball 10.

Uropods extending a little behind the rear projections of the last segment of the abdomen; most species (but not all) cannot roll into a ball 11.

10. Front margin of head indented in the middle; generally distributed; Family *Armadillidiidae*

Armadillidium Brandt

Front margin of head straight; California; Family *Cubaridae*

Cubaris Brandt

11. Largest of antennal segments about one-half the length of the divisions of the thorax; mouth parts forming a very conspicuous mass; Family *Trichoniscidae* 12.

Largest of antennal segments about as long as or longer than the divisions of the thorax; mouth parts not prominent 13.

12. Abdomen about the same width as the thorax

Haplophthalmus Schöbel

Abdomen abruptly narrower than the thorax

Trichoniscus Brandt

13. Abdomen abruptly narrower than the thorax; Family *Oniscidae* (part) 14.

Abdomen not abruptly narrower than the thorax 15.

14. With three sections in antennal flagellum

Philoscia Latreille

With two sections in antennal flagellum

Porcellionides Miers

(*Metoponorthus* Budde-lund)

15. With two sections in antennal flagellum; Family *Oniscidae* (part) 16.

With three or four sections in antennal flagellum 18.

16. Body very convex; can roll into a ball

Cylisticus Schnitzler

Body moderately convex; cannot roll into a ball 17.

17. With white respiratory sacs on five pairs of pleopods

Tracheoniscus Verhoeff

(*Trachelipus* Budde-Lund)

With white respiratory sacs on two pairs of pleopods

Porcellio Latreille

18. Posterior margin of last abdominal segment produced backwards in the middle to form a projection between the uropods

Oniscus Linn. (of Family *Oniscidae*)

Posterior margin of last abdominal segment regularly curved 19.

19. Front of head with a rounded lobe on each side; with four sections in antennal flagellum; Family *Scyphacidae*
Armadilloniscus Uljanin
(*Actoniscus* Harger)
Front of head with a horny tubercle on each side; with three sections in antennal flagellum
Alloniscus Dana (of Family *Oniscidae*)

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Hatch, M. H. 1947. The Chelifera and Isopoda of Washington. Univ. of Wash. Pub. in Biol., Vol. 10, No. 5. Pg. 155-274.

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Van Name, W. G. 1936. The American Land and Fresh-water Isopod Crustacea. Bull. Amer. Museum of Nat. History, Vol. 71. New York.

The names used as first choice in the Isopod key are those given in Van Name's Monograph.

KEY TO THE PRINCIPAL GENERA AND SPECIES OF DECAPODS

1. Carapace short and wide, much flattened dorso-ventrally, almost circular as viewed from above; abdomen bent forwards under cephalothorax; marine species, some of which may invade fresh water or occur on land near the sea
Crabs
Carapace elongate, not so much flattened; abdomen extending backwards 2.

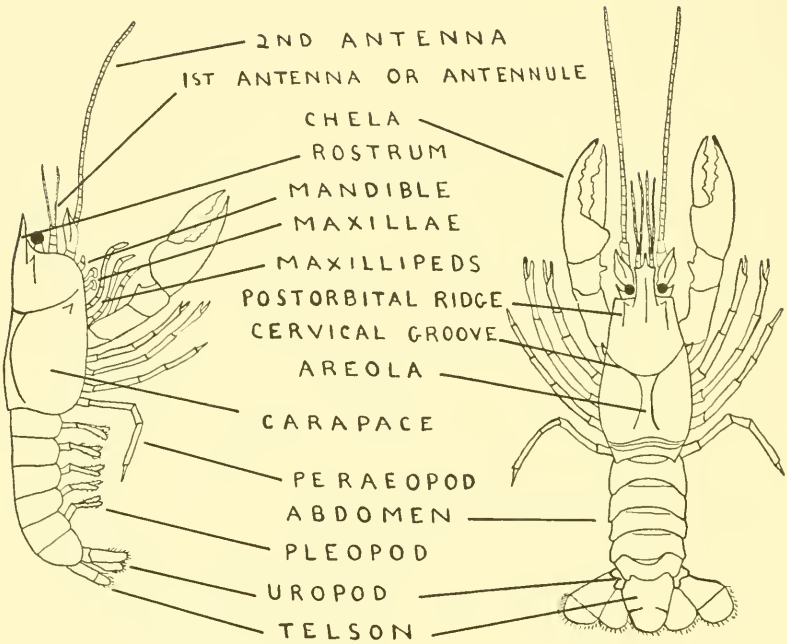
2. First two pairs of legs with opposing claws; mostly marine, but a few fresh-water species Shrimps and Prawns 3.
First three pairs of legs with opposing claws; fresh-water species; Family *Astacidae* Crayfishes (Crawfishes, Crawdads, etc.) 6.

3. With bunches of hairs on the ends of the claws; blind cave species; Kentucky; Family *Atypidae*
Palaemonias ganteri Hay Cave Shrimp
With scattered hairs on the claws; Family *Palaemonidae* 4.

4. With palps on mandible; second legs of male very long, with large claws; large enough to be used for food; Ohio and Mississippi Rivers
Macrobrachium ohionis (Smith) Great Shrimp
(*Palaemon ohionis* Smith)
No palps on mandibles; claws of first two legs about equal; about one to two inches long 5.

C. FAXONIUS SP. C. CAMBARUS SP. C ORTMANNICUS SP.

MALE CRAYFISH - 1ST ABDOMINAL APPENDAGES



SIDE VIEW DORSAL VIEW

DIAGRAM OF A MALACOSTRACAN

5. Blind species found in an artesian well in Texas
Palaemonetes antrorum Benedict Texas Blind Shrimp
With functional eyes; eastern states
Palaemonetes exilipes Stimpson Common Shrimp or Prawn

6. With a gill on each side (under carapace) of last segment of thorax; sexual characters not well developed (no seminal receptacle on ventral side of thorax of female; no hooks on third segments of walking legs of male; first appendages of abdomen (pleopods) of male simple); restricted to the Pacific slope except for one species which extends into the Yellowstone region (*C. clarkii* has been introduced into California); Subfamily *Astacinae* (Genus *Astacus* Fabricius (*Potamobius* Leach)) 7.
No gill on last segment of thorax; sexual characters well developed (in the female, a seminal receptacle, appearing as a round bony entrance, on ventral side of thorax; in the male, a hook or spine on third segments (counting from base of leg) of one or more pairs of walking legs; first appendages of abdomen (pleopods) of male with two or more tips); east of the Rocky Mountain region; Subfamily *Cambarinae* (former genus *Cambarus* Erichson) 11.

7. No spine on rear of postorbital ridge 8.
With a spine or tubercle on rear of postorbital ridge 9.

8. Sides of rostrum with fine serrations; Yellowstone region
Astacus gambelii (Girard)
Sides of rostrum smooth; northwest coast
Astacus klamathensis Stimpson

9. Sides of rostrum serrated
Astacus nigrescens Stimpson
Sides of rostrum smooth, except for a lateral spine on each side near tip 10.

10. Distance from cervical groove to lateral spines of rostrum more than two times posterior section of carapace; tip of rostrum longer than distance between lateral spines
Astacus leniusculus Dana
Distance from cervical groove to lateral spines of rostrum about two times or less posterior carapace; tip of rostrum about equal to distance between lateral spines
Astacus trowbridgii Stimpson

11. First pleopod of male (of the first form) with more than two tips, or with the outer tip truncated and bearing several (one to three) short horny teeth or projections 12.
First pleopod of male (of the first form) with two tips directed forwards or bent at right angles to the base 38.

12. With a hook (spine or tubercle) on third segment of second and third legs (in males of the first form); first pleopod of male with three slender, straight tips; Louisiana
Cambarellus shufeldtii (Faxon)
With a hook on third segment of third or of third and fourth legs (in males of the first form); first pleopod of male not so 13.

13. Third maxilliped enlarged; no teeth along inner margin of third segment of third maxilliped, but with strong setae instead; with a hook on third segment of third and fourth legs (in males of the first form); small, transparent species with unpigmented eyes; caves near Gainesville, Florida

Troglocambarus maclanei Hobbs

Third maxilliped normal; with teeth along inner margin of third segment of third maxilliped; with a hook on third segment of third or of third and fourth legs of male; *Procambarus* Ortmann (includes subgenera *Ortmannicus* Fowler (*Cambarus* Ortmann) and *Procambarus* Ortmann) 14.

14. Albinistic subterranean species, with eyes much reduced; Florida 15.

Well pigmented species, with normal eyes 17.

15. Hooks on third segments of third and fourth legs of male double tipped

Procambarus acherontis (Lönnberg)

Hooks on third segments of third and fourth legs of male simple pointed 16.

16. Movable claw of chela with about twelve tubercles on basal half of inner margin

Procambarus pallidus (Hobbs)

Movable claw of chela with about eighteen to twenty-one tubercles on basal half of inner margin

Procambarus lucifugus (Hobbs)

17. With hooks on third legs only (in males of the first form) 18.

With hooks on the third and fourth legs (in males of the first form) 22.

18. Areola not linear or obliterated 19.

Areola linear or obliterated for part of length 21.

19. First pleopod of male with three terminal processes; western species (N. Mexico, etc.)

Procambarus simulans (Faxon)

First pleopod of male with four terminal processes; in Florida 20.

20. Chela of male with hairs on inner margin of palm

Procambarus hubbelli (Hobbs)

Chela of male without hairs on inner margin of palm

Procambarus rathbunae (Hobbs)

21. Anterior border of side of carapace angled below the eye; sides of rostrum almost parallel; north-central states

Procambarus gracilis (Bundy)

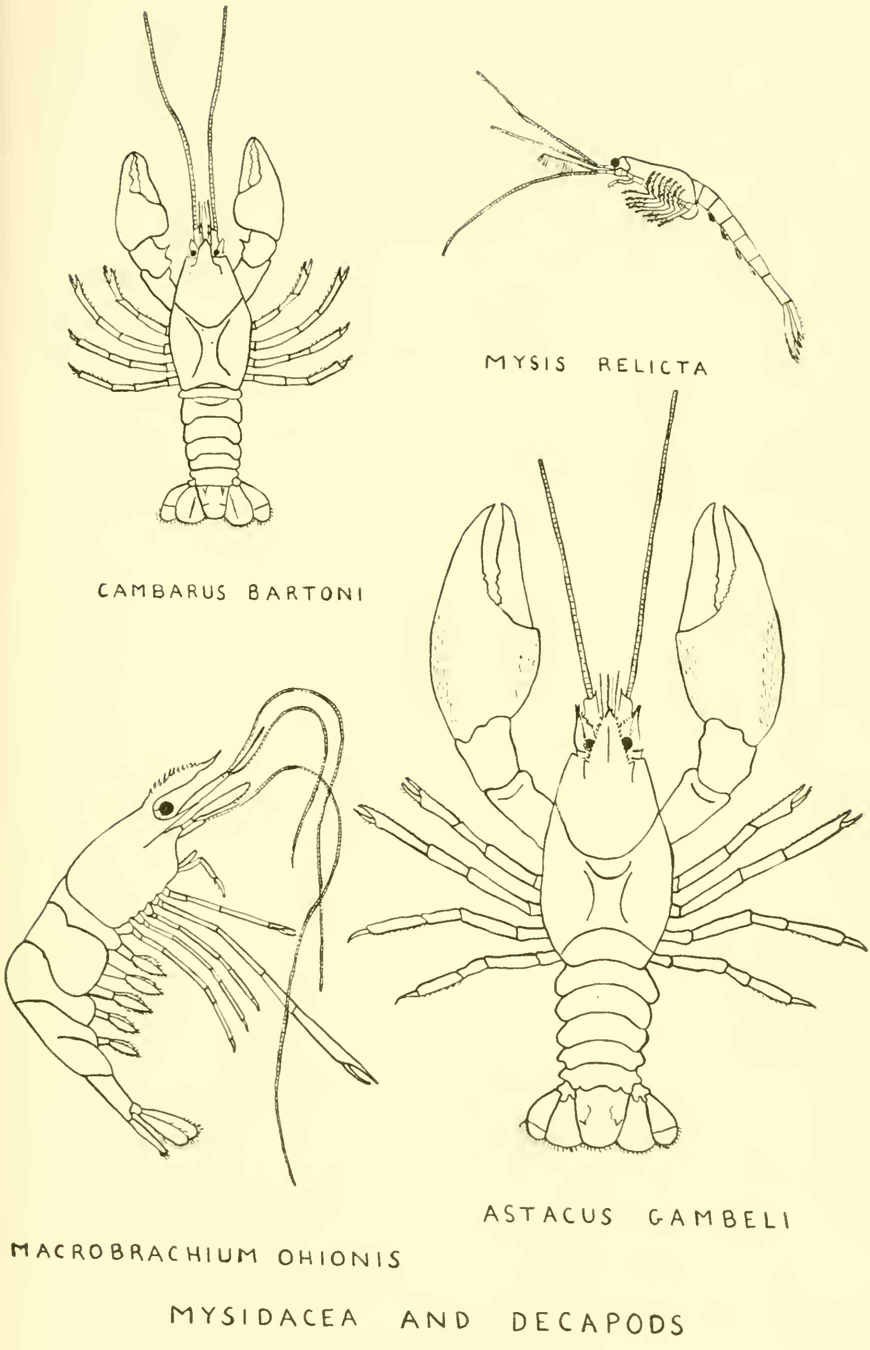
Anterior border of side of carapace almost straight; sides of rostrum more definitely converging toward the tip; southern states

Procambarus advena (Le Conte)

22. Posterior section of carapace considerably less than one-half as long as the anterior section; southern states 23.

Posterior section of carapace about one-half as long as the anterior section 29.

23. No spines on sides of carapace; rostrum without lateral spines; N. Carolina



MYSIDACEA AND DECAPODS

Procambarus pearsei (Creaser)

With one or two spines on each side of the carapace just behind the cervical groove (mid area, not at anterior extremity); usually with a spine on each side of the rostrum near the tip (sometimes lacking in *P. fallax*); southern states 24.

24. With two spines on each side of the carapace just behind the cervical groove 25.

With one spine on each side of the carapace just behind the cervical groove 26.

25. Sides of rostrum almost parallel; chela with many small tubercles

Procambarus versutus (Hagen)

Sides of rostrum more definitely converging; chela with scattered large tubercles

Procambarus spiculifer (Le Conte)

26. Rostrum almost flat above; areola about one-half as wide as long

Procambarus pubescens (Faxon)

Rostrum concave; areola narrower 27.

27. Sides of rostrum almost parallel

Procambarus angustatus (Le Conte)

Sides of rostrum more definitely converging 28.

28. Anterior section of carapace two and one-half times as long as the posterior section

Procambarus lecontei (Hagen)

Anterior section of carapace two and one-third times as long as the posterior section

Procambarus fallax (Hagen)

29. Areola linear or obliterated; southern states 30.

Areola not so 31.

30. Rostrum short, flat, and with very small lateral spines (one on each side near tip)

Procambarus troglodytes (Le Conte)

Rostrum longer, concave, and with strong lateral spines

Procambarus clarkii (Girard)

31. Outer branch of first pleopod of male with three small projections 32.

Outer branch of first pleopod of male with one or two rather plate-like projections 35.

32. Anterior margin of carapace angled below the eye; first pleopod of male with moderate tips extending forwards; widely distributed 33.

Anterior margin of carapace not angled; southern states 34.

33. Sides of rostrum almost parallel, with a strong spine on each side near tip

Procambarus blandingii (Harlan)

Sides of rostrum more sharply converging, with a weak spine on each side near tip

Procambarus blandingii acutus (Girard)

34. Areola narrow, with much curved sides; chela long and narrow; first pleopod of male straight

Procambarus hayi (Faxon)

Areola wider, with slightly curved sides; chela wider at base; first pleopod of male bent

Procambarus fallax (Hagen)

35. Proximal segment of telson with three or four spines on each side of rear margin; inner branch of first pleopod of male longer than outer branch; Florida

Procambarus alleni (Faxon)

Proximal segment of telson with two spines on each side of rear margin; inner branch of first pleopod of male not longer than outer branch 36.

36. With tufts of hair on inner margin of chela; southeastern U. S.

Procambarus barbatus (Faxon)

(*Procambarus penicillatus* (Le Conte))

No tufts of hairs on inner margin of chela 37.

37. Rostrum flat, with depressed tip; inner branch of first pleopod of male pointing straight forward; Arkansas

Procambarus viae-viridis (Faxon)

Rostrum more elevated; inner branch of first pleopod of male oblique; Florida

Procambarus evermanni (Faxon)

38. First pleopod of male with two tips, with one or both thickened and bent abruptly at right angles to base; with a hook (spine or tubercle) on third segment of third leg (in males of the first form); *Cambarus* Ortmann (formerly subgenus *Cambarus* Ortmann (*Bartonius* Ortmann)) 39.

First pleopod of male with two slender straight or curved tips; with a hook on third segment of third leg of male, sometimes on the fourth leg also; *Orconectes* Cope (formerly subgenus *Faxonius* Ortmann) 58.

39. Blind cave species 40.

With functional eyes 43.

40. No marginal spines on rostrum (one on each side near tip) 41.

Rostrum usually with marginal spines 42.

41. In the Ozark region

Cambarus setosus Faxon

In Florida

Cambarus cryptodytes Hobbs

42. Areola linear in the middle; Ozark region

Cambarus ayersi Steele

Areola wide; Tenn. and Alabama

Cambarus hamulatus (Cope & Packard)

43. With lateral spines on the rostrum (one on each side near tip) 44.

No lateral spines on the rostrum in the adult 48.

44. No lateral spines on the carapace; Ozark region

Cambarus hubbsi Creaser

With lateral spines on the carapace; southern states 45.

45. Antenna long and flattened, hairy along inner surface

Cambarus cornutus Faxon

Antenna smooth 46.

46. Sides of areola much curved
Cambarus jordani Faxon
Sides of areola not much curved 47.

47. Claws of chela about as long as the basal portion; lateral spines of carapace strong
Cambarus extraneus Hagen
Claws longer; lateral spines of carapace very small
Cambarus extraneus Hagen (var. *giardianus*)

48. Part of areola obliterated 49.
Areola not obliterated; eastern and central states to Texas 51.

49. Claws not hairy at base; widely distributed
Cambarus diogenes Girard
(*Cambarus obesus* Hagen)
Inner claw hairy at base 50.

50. Sides of rostrum converging; rostrum deeply hollowed out and with a lengthwise groove at base; widely distributed
Cambarus argillicola Faxon
Sides of rostrum almost parallel; rostrum shallow and scarcely grooved at base; Maryland
Cambarus uhleri Faxon

51. Areola narrow, one-third or less as wide as the rostrum 52.
Areola moderate to wide, usually more than one-half as wide as the rostrum 55.

52. Abdomen of normal length; thorax depressed
Cambarus latimanus (Le Conte)
Abdomen much shorter than the cephalothorax; thorax scarcely wider than deep 53.

53. Sides of rostrum converging
Cambarus carolinus (Erichson)
Sides of rostrum almost parallel 54.

54. Tip of rostrum indistinctly defined; color usually blue
Cambarus monongalensis Ortmann
Tip more distinct from rest of rostrum; color more often red
Cambarus dubius Faxon

55. Margins of rostrum not swollen
Cambarus montanus Girard
(*Cambarus bartoni acuminatus* (Faxon))
Margins of rostrum swollen 56.

56. With more than five dots in the narrowest part of the areola
Cambarus longulus Girard
With two to five dots in the narrowest part of the areola 57.

57. Sides of carapace curved; claws gaping at base
Cambarus bartoni (Fabricius)
Sides of carapace flattened; claws meeting throughout length
Cambarus bartoni robustus (Girard)

58. Tips of first pleopod of male very unequal in length, the inner tip being less than one-half the length of the outer tip; Miss. to Ala. and Okla. (Subgenus *Faxonella* Creaser)

Orconectes clypeatus (Hay)

Tips of first pleopod of male about equal 59.

59. Blind cave species; Ind., Kentucky and Alabama

Orconectes pellucidus (Tellkampf)

(Includes *O. inermis* Cope)

With functional eyes 60.

60. With a hook (spine or tubercle) on third segment of third and of fourth leg (in males of the first form); Missouri

Orconectes peruncus (Creaser)

With a hook on third segment of third leg of male 61.

61. Areola linear or partly obliterated; Tenn. south and west 62.

Not so 66.

62. Rostrum very long, making the anterior section of the carapace about three times as long as the posterior section

Orconectes lancifer (Hagen)

Rostrum shorter 63.

63. No lateral spines on the rostrum in the adult; Miss.

Orconectes mississippiensis (Faxon)

With lateral spines on the rostrum (one on each side near tip) 64.

64. First pleopod of male reaching only to third walking leg; basal part of first pleopod longer than tips

Orconectes difficilis (Faxon)

First pleopod of male longer, with the basal part about equal to or shorter than tips 65.

65. Antenna a little shorter than length of animal; basal part of larger claw of chela thick

Orconectes palmeri (Faxon)

Antenna a little longer than body; basal part of larger claw of chela thin

Orconectes palmeri (Faxon) (var. *longimanus*)

66. Both tips of first pleopod of male curving downwards in the same direction; with a tuft of hair at the inner base of chela (except in *O. compressus* and *O. harrisoni*) 67.

Tips of first pleopod of male either pointing straight ahead or not curving in the same direction 76.

67. First pleopod of male much thickened, with short, stout tips; chela wide at base, with claws gaping; Missouri

Orconectes harrisoni (Faxon)

First pleopod of male deeply split and more slender 68.

68. Inner claw of chela cut out at base; widely distributed

Orconectes immunis (Hagen)

Not so 69.

69. Posterior section of carapace a little less than one-half as long as the anterior section; southern states 70.

Posterior section of carapace one-half or more as long as the anterior section; rostrum short, with marginal spines (one on each side near tip) obscure or absent 72.

70. No ridge on rostrum; areola very narrow; claws very long and slender, about three times as long as the basal part of chela; Kansas and Ark.
Orconectes longidigitus (Faxon)
With central lengthwise ridge on the anterior part of the rostrum; areola short and wide; claws broad; Alabama 71.

71. No lateral spines on carapace; sides of carapace almost straight
Orconectes compressus (Faxon)
With a small spine on each side of the carapace; sides of carapace curved
Orconectes alabamensis (Faxon)

72. Sides of rostrum incurved, with lateral spines turned upwards; Arkansas
Orconectes meeki (Faxon)
Sides of rostrum straight; lateral spines of rostrum not turned upwards 73.

73. Tips of first pleopod of male only slightly curved 74.
Tips of first pleopod of male shorter and much curved 75.

74. Areola narrow; rostrum hollowed out; Ala.
Orconectes validus (Faxon)
Areola broader; rostrum almost flat; central states
Orconectes virilis (Hagen)

75. Chela with small hairs; Kansas
Orconectes pilosus (Hay)
Chela without hairs, except for tuft at base; Kansas
Orconectes nais (Faxon)

76. First pleopod of male reaching to the base of the third leg 77.
First pleopod of male reaching to the first or second leg 82.

77. Tips of first pleopod of male rather thick and slightly split, tapering to a point 78.
Tips of first pleopod of male deeply split and more slender throughout 80.

78. Tips of first pleopod of male pointing obliquely in opposite directions; Kentucky, Ind.
Orconectes sloanii (Bundy)
Tips of first pleopod of male crossing each other 79.

79. Sides of rostrum straight; sides of carapace before cervical groove spiny; widely distributed
Orconectes limosus (Raf.)
(*Cambarus affinis* (Say))
Sides of rostrum concave; sides of carapace granular; Ind.
Orconectes indianensis (Hay)

80. Rostrum almost flat, without a ridge; with a shoulder on anterior margin of first pleopod of male; N. Y., Penna.
Orconectes obscurus (Hagen)
Rostrum somewhat hollowed out; no shoulder on anterior margin of first pleopod of male 81.

81. With a ridge on the rostrum; widely distributed
Orconectes propinquus (Girard)
No ridge on the rostrum; east-central states
Orconectes propinquus sanborni (Faxon)

82. First pleopod of male reaching to the base of the second leg 83.
First pleopod of male reaching to the base of the first leg 87.

83. Chela wide, spotted, lengthwise grooved; bony entrance to seminal receptacle of female nearly round; Arkansas
Orconectes menae (Creaser)
Not so 84.

84. Outer tip of first pleopod of male blade-like; Ozark region
Orconectes luteus (Creaser)
Outer tip of first pleopod of male spine-like or setiform 85.

85. Sides of rostrum almost parallel; outer tip of first pleopod of male tapering; Tenn. and Georgia
Orconectes erichsonianus (Faxon)
Sides of rostrum more definitely converging; outer tip of first pleopod of male uniformly slender throughout; east-central states 86.

86. Rostrum with a faint ridge; tip not upturned
Orconectes forceps (Faxon)
No ridge on rostrum; tip of rostrum upturned
Orconectes rusticus (Girard)

87. Posterior section of carapace a little less than one-half the anterior section; southern states
Orconectes spinosus (Bundy)
Posterior section of carapace one-half or more as long as the anterior section 88.

88. Sides of rostrum thickened, converging; Missouri
Orconectes hylas (Faxon)
Sides of rostrum scarcely thickened, parallel 89.

89. Postorbital and lateral spines of carapace small or absent; with a prominent ridge on the rostrum; Mo., Colo.
Orconectes neglectus (Faxon)
With sharp postorbital and lateral spines on the carapace; with an obscure ridge on the rostrum; Ky., Ind.
Orconectes putnami (Faxon)

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ARACHNIDA

The *Arachnida* are characterized by an absence of antennae and by four pairs of legs in the adult. Many people erroneously call them insects. Although there are many hundreds of species of *Arachnida* in the United States, little general information is available about many of them. In addition to the spiders, the group contains the mites and ticks, the scorpions, and the harvestmen or daddy-long-legs.

Sometimes also included with the *Arachnida* are the microscopic, aquatic creatures called *Tardigrada* or Water Bears. Their common name refers to the odd profile they sometimes present under the microscope. Actually they have cylindrical, unsegmented bodies and four pairs of short legs, each ending in several hooks or claws. They have no respiratory, circulatory or excretory organs and are considered either the most primitive or the most degenerate of the *Arthropoda*.

The mites are the most variable in structure of the *Arachnida* and many are peculiarly adapted to a semiparasitic or parasitic life upon other animals. The larger forms, usually called ticks, frequently carry and transmit protozoan diseases from one host to another. Most of the mites differ from the rest of the *Arachnida* in that they may have larval stages in which only six legs are present, a fact that often misleads the amateur taxonomist. One family of mites lives in the hair follicles of mammals and brings on the condition known as mange. The red "spider", which is often a serious pest in greenhouses, and the cheese mite are other examples of this group. The "jigger" or harvest mite is seldom seen but its effects on the human skin are only too evident. One family of mites lives in fresh water.

The scorpions rate a position at the other end of the group, if we consider size, for they are the largest of the *Arachnida,* some tropical forms attaining a body length of eight inches. The native species occur in the southern and western states. Their large, crab-like claws and the long abdomen ending in a poison sting identify them at once. Like many other animals possessing poison glands, they are not aggressive, but use their poison weapons only in self defense. They are nocturnal and carnivorous, feeding on insects and spiders. Unlike most of the other *Arthropoda,* they bring forth living young, which are carried for some time attached to the body of the mother.

The harvestmen or daddy-long-legs are common all over the world. They spin no webs, as do most of the spiders, although they feed upon insects. Only three pairs of legs are commonly used for locomotion, the first pair apparently serving as sensory appendages or feelers. The ease with which they lose legs is familiar to every country child and may be a defensive mechanism. They have few natural enemies, however, for they excrete an ill-smelling fluid when disturbed. In the northern states the eggs are laid in the fall and hatch in the spring into small, white creatures with black eyes.

The true spiders have two evident body divisions, the cephalothorax or fused head and chest, and the abdomen. Their elaborate webs are sure to attract attention even where the animals themselves are overlooked. Not all spiders spin webs, however. An interesting sequence may be arranged, starting with the spiders such as the crab and jumping spiders, which spin no webs. Then we may consider those that leave a guide line or safety thread wherever they travel. Other spiders weave silken tubes for retreats or hiding places. Still others extend this tube into a funnel, which functions as a trap for their prey. Some have carried the process further and make elaborate snares. Those of some species are like inverted bowls and catch insects as they fly upwards. Other webs are concave and are hung where aphids and other insects may drop into them. The orb spiders make the most attractive and geometrically perfect webs.

In addition to providing shelter and ensnaring food the silk often serves as a swing or even as a balloon and aids in the dispersal of spiders. Some are known to have landed with their delicate parachutes on ships far out at sea, and the presence of common spiders on widely scattered islands may be attributed to this efficient method of travel. Several attempts have been made to utilize spider silk for spinning. The silk, although much finer than that of the silkworm, retains its elasticity well and can be woven into cloth. The chief argument against its use lies in the difficulty in feeding spiders and in keeping many peaceably together. The silk, because of its fineness, is utilized for cross hairs in several types of surveying instruments.

Contrary to general impressions the spiders are not naturally aggressive to man and only a few of them will bite, even when roughly handled. Only one of the common spiders, the black widow, is dangerously poisonous. This spider belongs to the *Theridiidae*, or Comb-footed Spiders, which differ from all other families of spiders by the presence of a "comb" or regular row of serrated bristles along the inner side of the last segment of each hind leg. This comb is discernible only under a lens. The black widow may be distinguished from the other Comb-footed Spiders by having the eyes on each side well separated rather than adjacent, by its large globose abdomen and by its jet-black color. Most of these spiders have red and yellow markings on the abdomen, the most characteristic being an hour-glass shaped patch on the under side. These markings vary, however, and may be completely absent. Adults are about one-quarter to one-half an inch long. They are most abundant in the southern states, but may occur anywhere in the United States.

In most species of spiders the male is considerably smaller than the female and is a poor spinner. He may occasionally be found living as a dependent at one edge of the female's web and taking the leavings of her feasts. The female usually shows great solicitude for her young. A large mass of eggs is usually securely enclosed in a large "nest" of silk, which may be spherical or discoidal. In most species the case is fastened in some sheltered location or placed under a rock or loose piece of bark. A few species carry their egg cases with them, either attached to the abdomen or clutched by the mouth appendages.

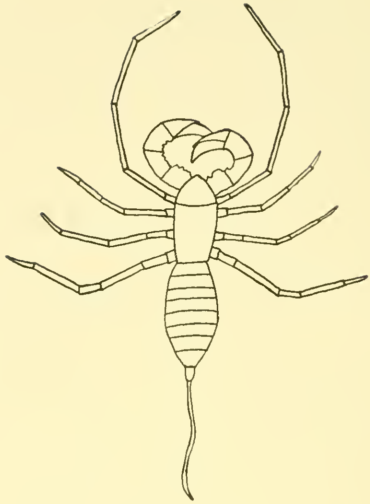
The most spectacular of the spider group are those commonly called tarantulas, many of which are dangerously poisonous. The most famous tarantula, the effects of whose bite could supposedly be warded off only by performing a vigorous dance which came to be called the tarantella, is a native of Europe. The large, hairy spiders of the southern and southwestern states have long attracted wide attention. The most remarkable of these are the trap-door spiders, which excavate in the soil deep burrows topped by hinged lids, line them with a plaster of saliva and earth, and usually add an additional lining of web. The members of another group are called the running tarantulas or bird spiders. They are the largest of the tarantulas, one South American species having a body two inches long and a leg span of seven inches. Some of the early descriptions of this spider record its ability to capture small birds. Although its usual fare consists of insects, and the capture of birds is probably rare, the more dramatic event was naturally more noted and gave the spider its common name, as well as the generic name of *Avicularia*. A third group of the tarantulas spin webs. One of the most peculiar of these is the purse-web tarantula, which not only lines its burrow at the base of a tree with web, but also extends the web as a straight tube for about a foot above ground against the tree trunk. When some unwary insect uses this conveniently placed ladder, the spider runs up the inside of the tube and bites the unlucky insect through the web. It then cuts the web, sucks the juices of its prey, and patches up the trap ready for the next comer.

The unfortunate prejudice that exists against spiders in general is probably due to fear of tarantulas and to ignorance of their nature and habits. Wherever their presence and their webs are not objectionable, the spiders should be left undisturbed to play their part in destroying insects and other undesirable small organisms.

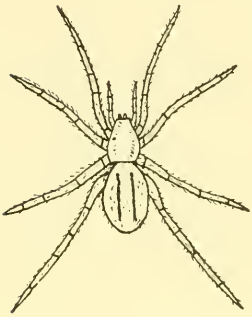
KEY TO THE ORDERS OF ARACHNIDA

1. Microscopic aquatic animals; legs without distinct segments; last pair of legs projecting from the posterior end of the body; (often grouped as a class by many writers)
   Tardigrada Water Bears
   Not usually microscopic; aquatic or terrestrial; legs segmented and on sides of body — 2.
2. Abdomen unsegmented — 3.
   Abdomen segmented (sometimes evident only on under side) — 4.
3. Cephalothorax divided from the abdomen by a deep constriction through the middle of the body; with four pairs of legs
   Araneida or *Araneae* Spiders and Tarantulas
   Head and thorax not distinct from the abdomen; with two or four pairs of legs in the adult; usually with three pairs of legs in the young
   Acarina Mites, Ticks etc.
4. With a tail-like projection from the end of the abdomen — 5.
   Abdomen without any tail-like projection — 7.
5. With a sting; first pair of legs shorter than the rest
   Scorpionida Scorpions
   No sting; first pair of legs longer than the rest — 6.
6. Tail-like portion with bristles
   Palpigradi or *Microthelyphonida* Microscorpions
   Tail-like portion smooth
   Pedipalpi, Families *Shizonotidae* and *Thelyphonidae* Tailed Whip-scorpions
7. Sides of animal outcurved or straight; pedipalps (second pair of mouth appendages) with or without opposing claws — 8.
   With a constriction between head and thorax or between thorax and abdomen; no opposing claws on pedipalps — 9.
8. With opposing claws on pedipalps; animal long and narrow, wider posteriorly; legs moderate
   Chelonethida or *Pseudoscorpionida* False Scorpions
   No opposing claws on pedipalps; animal ovoid; legs extremely long and slender
   Phalangiida Harvestmen or Daddy-long-legs
9. Head constricted from thorax; body not flattened
   Solpugida Solpugids
   With a narrow constriction between the cephalothorax and the abdomen; body broad and flat
   Pedipalpi, Family *Tarantulidae* or *Phrynidae*
   Tailless Whip-scorpions (Not Tarantulas)

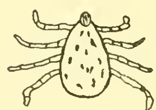
WATER BEAR (MAGNIFIED)



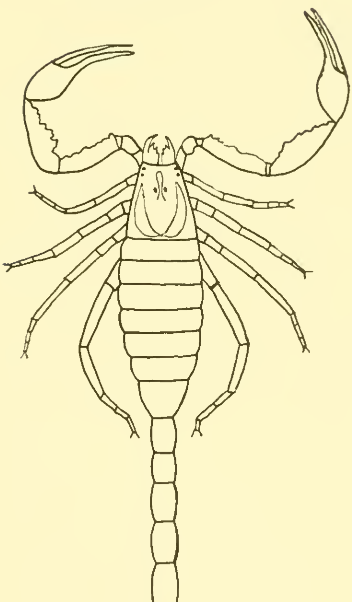
TAILED WHIP-SCORPION



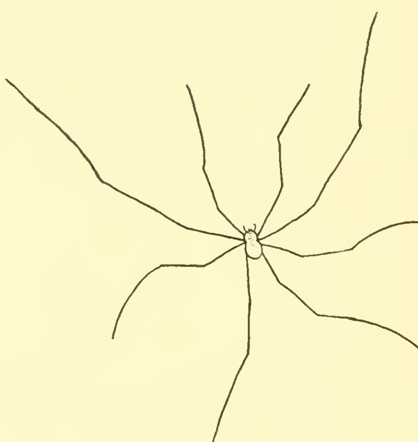
SPIDER



TICK



SCORPION



HARVESTMAN

SUBCLASS ARACHNIDA

KEY TO THE FAMILIES AND GENERA OF SCORPIONS

1. With two eyes on each side of the cephalothorax (besides the ones near the mid-line); Cal.
   Chactidae, Broteas Koch

   With three or more eyes on each side of the cephalothorax 2.

2. Sternum triangular—*Buthidae* 3.

   Sides of sternum parallel 6.

3. With oblique rows of tiny, spiny projections on the claws of the pedipalps, with a row of smaller spines on either side and parallel to them; southern U. S.
   Centrurus Ehrenberg

   With oblique rows of tiny, spiny projections on the claws of the pedipalps, unaccompanied by parallel rows of smaller spines 4.

4. No spine under sting; third and fourth legs with a spur at the distal end of the first tarsal segment; Texas, Cal.
   Uroplectes Peters

   With a spine under the sting; fourth legs without a spur at the distal end of the first tarsal segment 5.

5. With the rows of spines overlapping; Fla.
   Tityus Koch

   With the rows of spines almost end to end; Fla. to Cal.
   Isometrus Hemprich & Ehrenberg

6. With one spur on the outside of the last segment of the last leg
   Scorpionidae 7.

   With one or two spurs on each side of the last segment of the last leg
   Vejovidae 8.

7. With a knob below the sting; southern U. S.
   Diplocentrus Peters

   No knob below the sting; Fla.
   Opisthacanthus Peters

8. Movable claw of chelicerae (first pair of mouth appendages) without teeth; southern states
   Vejovis Koch

   Movable claw of chelicerae with one or more teeth below 9.

9. Middle area of combs (area between the "teeth" and the "back" of the combs, a pair of which are situated on the front of the lower side of the abdomen) composed of eight pieces each; southwestern states
   Hadrurus Thorell

   Middle area of combs composed of six or less pieces 10.

10. With three or less teeth on the movable claw of the chelicera; southwestern states
    Anuroctonus Pocock

    With four or more teeth on the movable claw of the chelicera; West Coast
    Uroctonus Thorell

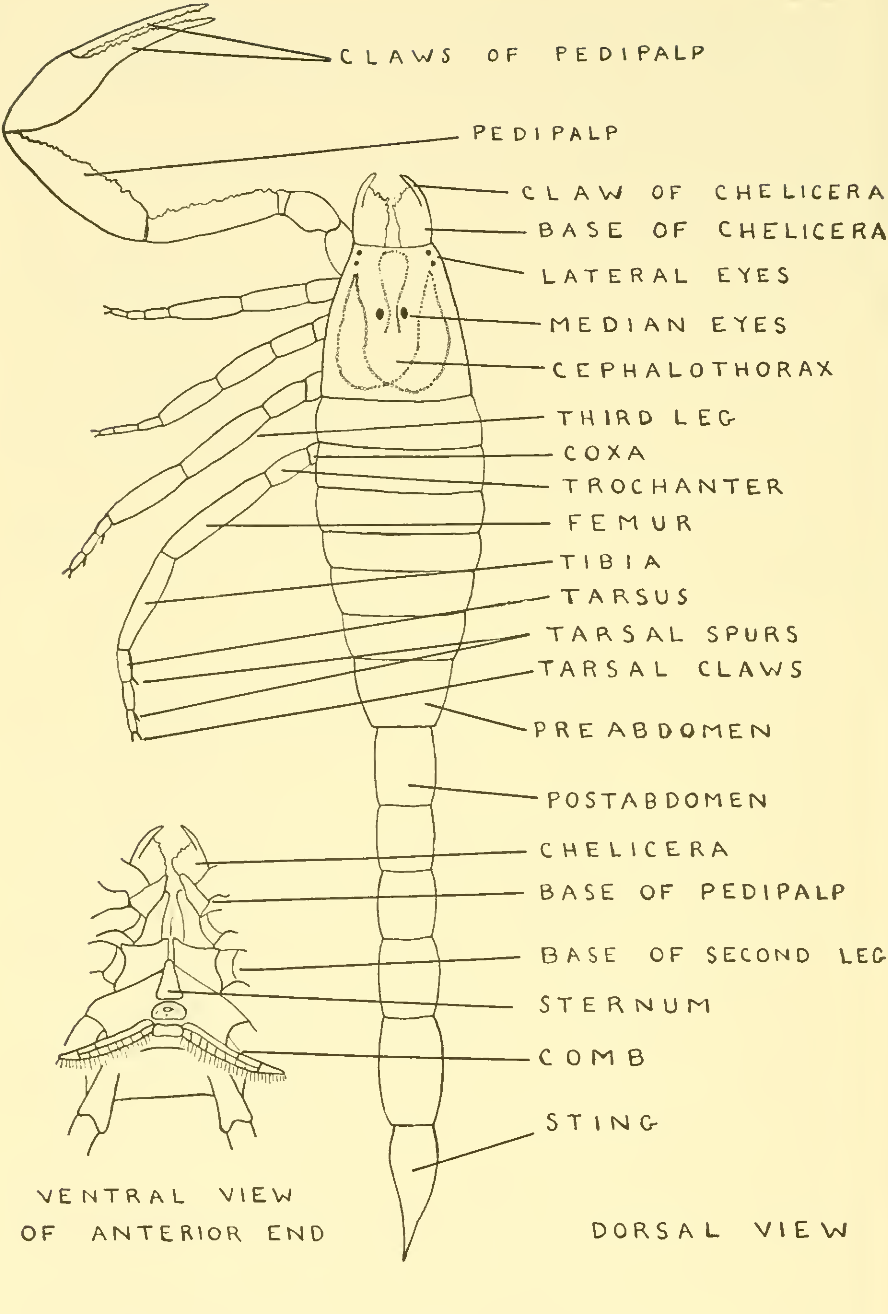


DIAGRAM OF A SCORPION

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KEY TO THE PRINCIPAL FAMILIES OF SPIDERS

1. With the large basal segments of the chelicerae (first pair of mouth appendages) projecting forwards and with the claws moving up and down parallel to each other; with two pairs of book lungs; mostly in the south—The Tarantulas 2.
   Basal segments of chelicerae usually projecting downwards and the claws moving in the same plane or somewhat obliquely towards and away from each other; only one pair of book lungs, except in one family with extremely long and slender legs; widely distributed—
   The Spiders 5.

2. Pedipalps (second pair of mouth appendages) each with a distinct endite (small lobe-like structure arising from the basal segment)
   Atypidae Purse-web Spiders
   Endites of pedipalps indistinct or wanting 3.

3. With a rake on the chelicera (outer end of basal segment of chelicera armed with teeth)
   Ctenizidae Trap-door Spiders
   No rake on the chelicera 4.

4. Ends of legs with two claws and a bunch of hairs
   Theraphosidae Bird Spiders
   (*Aviculariinae*)
   Ends of legs with three claws and no bunch of hairs
   Dipluridae Funnel-web Tarantulas

5. With four respiratory openings (either with two pairs of lung spiracles or with one pair of lung spiracles and one pair of tracheal spiracles) 6.
   With three respiratory openings (with one pair of lung spiracles and a single tracheal spiracle) 10.

6. With two pairs of book lungs; legs very long and slender; Tennessee
   Hypochilidae Four-lunged Spiders
   With one pair of lung spiracles and one pair of tracheal spiracles 7.

7. With eight eyes grouped together on a low median knob towards the front of the cephalothorax; with cribellum and calamistrum present (except in adult males)
   Filistatidae Filistatids
   With six eyes; cribellum and calamistrum absent 8.

8. Basal segments of all legs short and stout
   Oonopidae Oonopids
   Basal segments of first two legs slender 9.

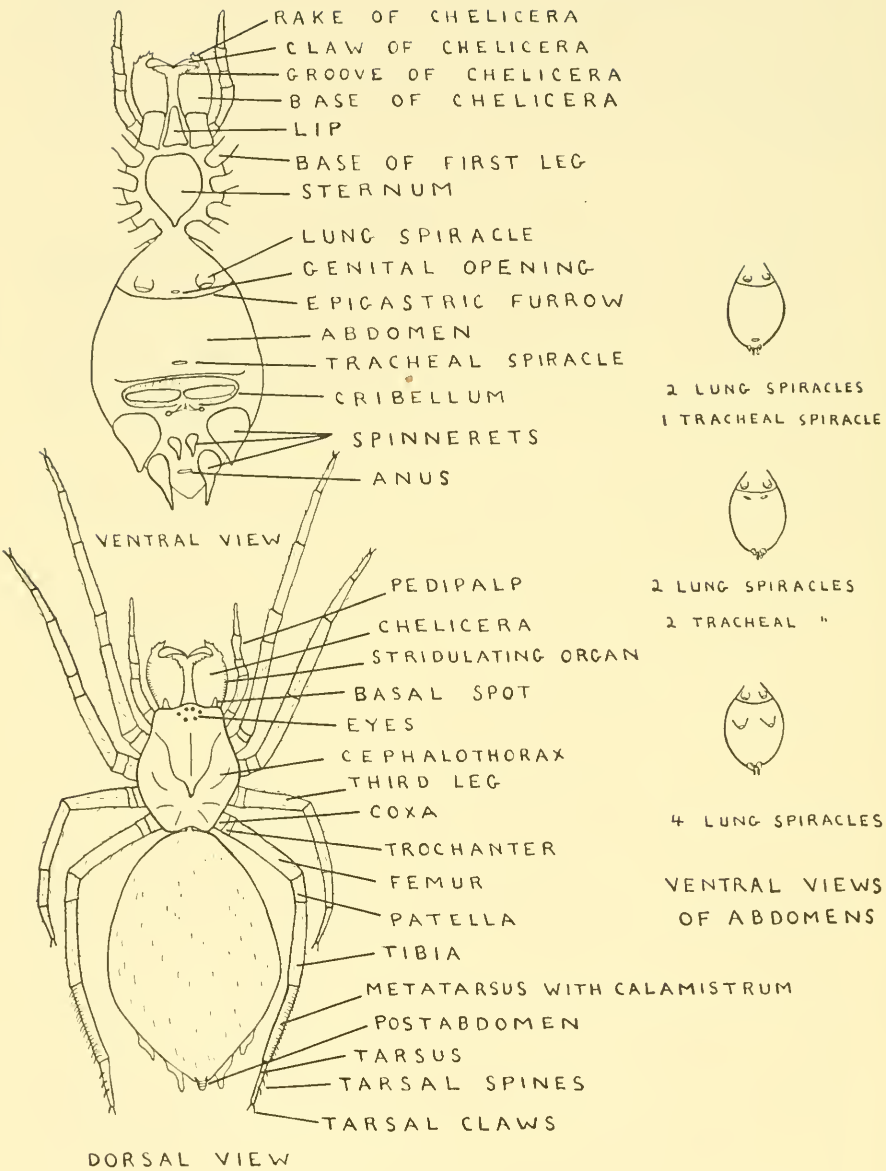

DIAGRAM OF A SPIDER

9. Eyes in more or less circular arrangement
Dysderidae Dysderids
With three groups of two eyes each
Segestriidae Segestriids

10. Ends of legs with two claws and usually a bunch of hairs 11.
Ends of legs with three claws and usually no bunch of hairs 20.

11. With six eyes (all white)
Sicariidae Sicariids
(*Scytodidae*)
Usually with eight eyes 12.

12. Eyes in three (rarely four) rows (4-2-2 or 2-4-2) 13.
Eyes in two rows (4-4 or 6-2) 16.

13. Chelicera very large with a slender claw about as long as the basal portion; damp and dark places in the south
Prodidomidae Prodidomids
Chelicera moderate; claw shorter 14.

14. Eyes in three or four rows, the last row situated one-third to one-half way back from the front of the cephalothorax
Salticidae Jumping Spiders
(*Attidae*)
Eyes in three rows on the front of the cephalothorax 15.

15. Eye formula 4-2-2
Zodariidae Zodariids
Eye formula 2-4-2
Ctenidae Wandering Spiders

16. First pair of spinnerets long and well apart; legs about equal
Drassodidae Drassodids
(*Drassidae*)
First pair of spinnerets close together 17.

17. Legs about equal; inner margin of groove of chelicera toothed
Clubionidae Clubionids
First two pairs of legs larger than the others and directed sideways, or inner margin of groove of chelicera smooth, or both Crab Spiders 18.

18. Inner margin of groove of chelicera smooth; widely distributed
Thomisidae Crab Spiders
Inner margin of groove of chelicera toothed; tropical species 19.

19. Eye formula 6-2 (six eyes in first row, two in second row)
Selenopidae Tropical Crab Spiders
Eye formula 4-4
Eusparassidae Giant Crab Spiders
(*Sparassidae*)
(*Heteropodidae*)

20. With six spinnerets in one transverse row
Hahniidae Hahniids
With six spinnerets normally arranged or rarely with only two spinnerets 21.

21. Eyes unlike in color or rarely absent 22.
Eyes either all dark or all light 34.

22. Anal tubercle enlarged and fringed with long hairs 23.
Anal tubercle normal 24.

23. With a cribellum and calamistrum (except in adult males)
Oecobiidae Oecobiids
No cribellum and calamistrum
Urocteidae Urocteids

24. Tibia and metatarsus of first two legs with a regular row of alternating long and short spines (two long, several short, etc.)
Mimetidae Mimetids
Not so 25.

25. Chelicerae joined together at base; tracheal spiracle situated slightly behind the lung spiracles 26.
Chelicerae free; tracheal spiracle normally situated slightly before the spinnerets 27.

26. Eyes grouped together on a low, median knob on the front of the cephalothorax
Filistatidae Filistatids
Eyes in two to three rows; legs very long and slender
Pholcidae Pholcids

27. With a cribellum and calamistrum (except in adult males) 28.
No cribellum and calamistrum 29.

28. With a single row of hairs in the calamistrum
Dictynidae Dictynids
With a double row of hairs in the calamistrum
Amaurobiidae Amaurobiids

29. Tarsi without serrated bristles 30.
Tarsi of some of the legs with serrated bristles 31.

30. No basal spot on the chelicera; spinnerets two or six
Zodariidae Zodariids
With a basal spot on the chelicera; spinnerets six
Agalenidae Funnel-web Spiders

31. Tarsus of fourth leg with a comb (a regular row of serrated bristles) on the inner surface
Theridiidae Comb-footed Spiders
Bristles, if present on the tarsus of the fourth leg, not so regularly arranged 32.

32. No stridulating organ on the chelicera; eyes eight; making orb webs
Argiopidae Orb Weavers
(*Epeiridae*)
Outer side of the chelicera with a stridulating organ (rasp-like structure); eyes eight or rarely absent; making sheet webs 33.

33. With spines on the legs
Linyphiidae Sheet-web Spiders

No spines on the legs
Erigonidae Erigonids
(*Micryphantidae*)

34. Eyes all white 35.
Eyes all dark 39.

35. Legs extremely long and slender (about four times the length of the body) and chelicerae each with two short opposing claws
Pholcidae Pholcids
Not so 36.

36. No bristles on tarsi; last pair spinnerets long and often two-jointed
Agalenidae Funnel-web Spiders
With serrated bristles on tarsi 37.

37. Chelicerae joined together at base; eyes usually six
Sicariidae Sicariids
(*Scytodidae*)
Chelicerae free; eyes six or eight 38.

38. With six eyes
Leptonetidae Leptonetids
With eight eyes
Argiopidae Orb Weavers
(*Epeiridae*)

39. With a cribellum and calamistrum (except in some adult males); posterior metatarsi with a series of curved spines below
Uloboridae Uloborids
Not so 40.

40. Trochanters each with a distinct, rounded notch in the outer, ventral margin 41.
Trochanters not notched (except sometimes the fourth) 42.

41. Eyes in three rows, the first row with four small eyes and the second and third rows each with two large eyes; hair on integument simple
Lycosidae Wolf Spiders
Eyes usually in two rows, with the posterior row only slightly recurved; hair on integument plumose; legs long
Pisauridae Nursery-web Spiders

42. Eyes unequal in size
Oxyopidae Oxyopids
Eyes about equal 43.

43. No spines on tarsi; posterior spinnerets long and often two-jointed
Agalenidae Funnel-web Spiders
Tarsi with serrated spines; posterior spinnerets not much longer than the anterior pair
Argiopidae Orb Weavers
(*Epeiridae*)

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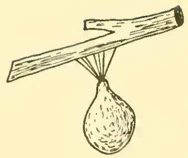
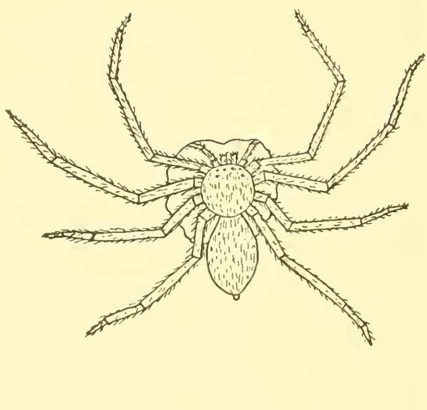
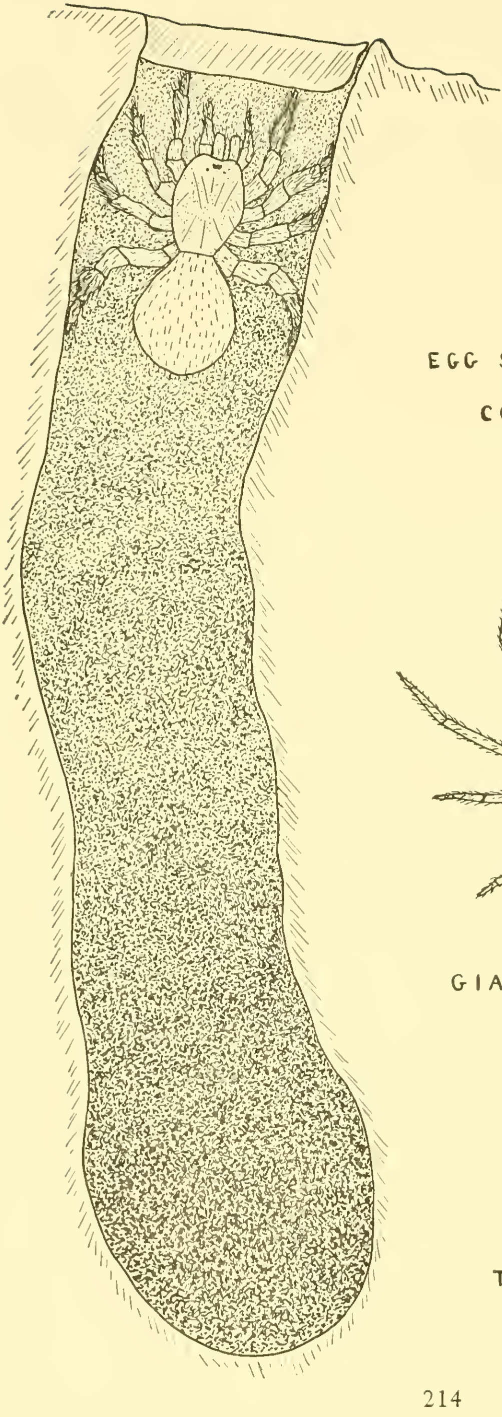


EGG SAC OF ONE OF THE COMB-FOOTED SPIDERS



GIANT CRAB SPIDER WITH EGG SAC



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The family names used as first choice in the spider key are those given in Petrunkevitch's Catalogue.

MYRIAPODA

The *Myriapoda* are known to most people as centipedes and millipedes or hundred-legs and thousand-legs, but their small economic importance and the difficulty of identification have left them generally disregarded. All of them are terrestrial, air-breathing animals. Representatives of the group are to be found in almost all parts of the world. A few, such as the house centipede, *Scutigera,* occasionally cause the housewife much consternation by unexpected appearances in bathtubs and sinks. Others are common in gardens, some feeding on plant roots and some preying on earthworms and insects. These are commonly called wireworms, a popular name which is frequently applied to the larval forms of several kinds of beetles. Many of the group are so small as to escape notice, and even the largest forms in the United States are seldom longer than six inches.

The classification is not fully agreed upon and the term *Myriapoda* is retained for the group largely as a matter of convenience rather than as implying any close relationship between the four subdivisions it contains. Even the common names of millipede and centipede are unsatisfactory, as many of the centipedes actually have more legs than do the millipedes.

Related to the *Diplopoda* or millipedes are two groups of small, soft-bodied forms, the *Symphyla* and the *Pauropoda*. The latter two are not good material for fossilization, but the *Diplopoda* are to be found as fossils in Carboniferous rocks and a few in Devonian sandstone. They seem to be most nearly related to the annelid worms and to be the most ancient of the *Myriapoda*. The *Diplopoda* usually have two pairs of legs on each of most of the body segments and are commonly called millipedes or thousand-legs. Their bodies may be either cylindrical or flat and the chitin is usually reinforced with lime, as in the *Crustacea*. They are protected from many of their natural enemies by the presence of "stink glands", which in some forms are said to be so powerful that collectors may utilize one or two in a jar as an efficient, emergency "killing bottle" for other forms. They are generally herbivorous and some of them have become serious greenhouse pests, eating the roots of plants.

The *Chilopoda* or centipedes are mainly carnivorous and many of them possess poison fangs. The larger, tropical species can inflict wounds that are dangerous even to man. Their internal anatomy shows them to be more advanced than the *Diplopoda* and probably more nearly related to the insects than they are to the millipedes. The fossil record also indicates that they are of more recent origin than the millipedes, for they are first found in any quantity as fossils in the Oligocene amber.

KEY TO THE ORDERS OF MYRIAPODA

1. With branched antennae; animals very small
   Pauropoda
   Antennae not branched 2.
2. With two claws on the end of each leg; animals very small
   Symphyla
   With one claw on the end of each leg; animals occasionally minute 3.
3. Opening to reproductive organs near the posterior end of the body; male gonopods (feet modified for copulation) inconspicuous or absent; with one pair of legs to most of the dorsal plates, except in one genus with very long legs, which has two
   Chilopoda Centipedes or Hundred Legs
   Openings to reproductive organs near the anterior end of the body; with one or both pairs of legs on the seventh segment of the male modified for reproduction; most of the segments with two pairs of legs in the adult
   Diplopoda Millipedes or Thousand Legs

KEY TO THE COMMON GENERA OF PAUROPODA

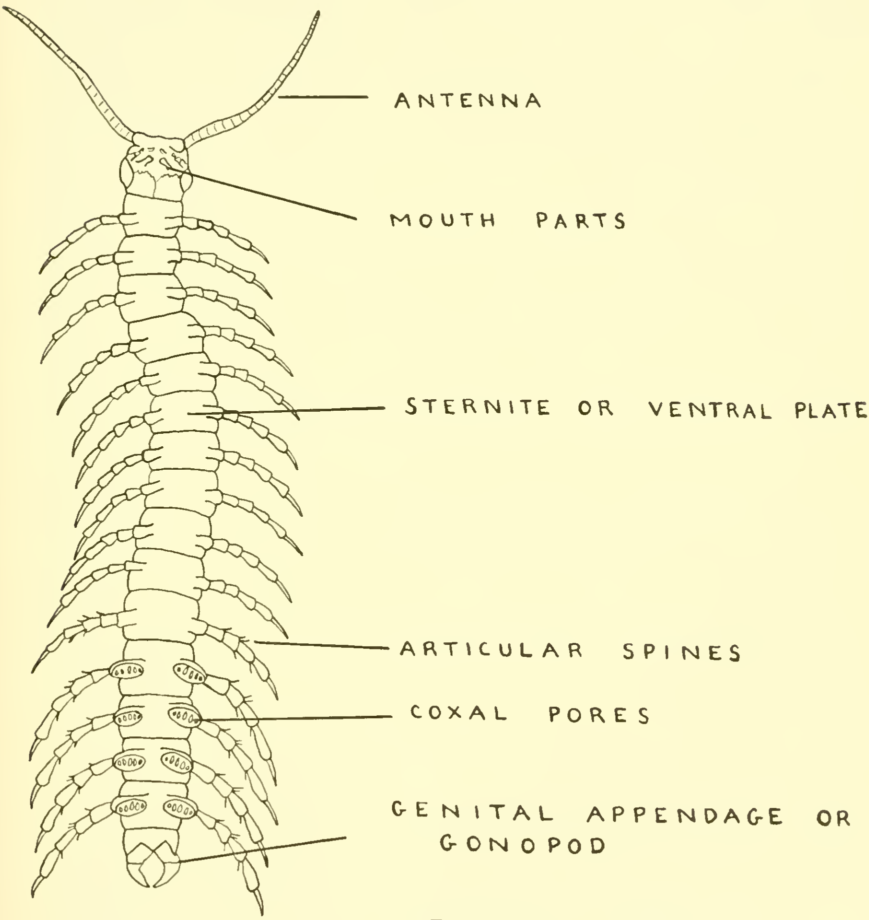
1. Body over three times as long as wide
   Pauropus Lubbock
   Body less than three times as long as wide
   Eurypauropus Ryder

KEY TO THE COMMON GENERA OF SYMPHYLA

1. Dorsal plates rounded or emarginate behind; first pair of legs evident
   Scutigerella Ryder

FRONT VIEW VENTRAL VIEW

DIAGRAM OF THE HEAD OF A MILLIPEDE



VENTRAL VIEW

DIAGRAM OF A CENTIPEDE

Dorsal plates with two points behind; first pair of legs reduced
Scolopendrella Gervais

KEY TO THE COMMON GENERA OF DIPLOPODA OR MILLIPEDES

1. Integument soft; animals cannot roll into a ball or spiral
Polyxenidae, Polyxenus Latreille
Integument stiff; usually capable of rolling into a ball or spiral 2.

2. Mouth parts suctorial *Polyzoniidae* 3.
Mouth parts biting 4.

3. With eyes
Polyzonium Brandt
Without eyes
Platydesmus Lucas
(*Brachycybe* Wood)

4. With nineteen to twenty-one segments; body usually flattened; *Polydesmidae*
With more than twenty-five segments; body cylindrical 11.

5. With a deep transverse furrow on the dorsal plates
Oxidus Cook
(*Paradesmus* Saussure)
No transverse furrows on dorsal plates 6.

6. With a spine on the lower side of the base of each leg
Fontaria Gray
No spines on bases of legs 7.

7. Anal segment truncate; body usually brightly spotted
Euryurus Koch
Anal segment pointed behind 8.

8. Tubercles absent or scattered on dorsal plates 9.
Tubercles in two to five transverse rows on dorsal plates 10

9. Back curved; color brown
Leptodesmus Saussure
Back more flattened; color white
Chaetapsis Bollman

10. With two or three rows of tubercles across the dorsal plates
Scytonotus Koch
With four or five rows of tubercles across the dorsal plates
Polydesmus Latreille

11. Segments twenty-six to thirty; anal segment ending in two papillae; *Craspedosomidae* 12.
Usually with more than thirty segments; anal segment curved or ending in a spine 17.

12. Adult segments twenty-eight
Trichopetalum Harger

(*Craspedosoma* Leach (part))
(*Scotherpes* Cope (part))
Adult segments thirty 13.

13. With pronounced ridges or keels 14.
Ridges or keels indistinct 15.

14. Promentum triangular; ninth pair of legs of male with four joints and a claw
Pseudotremia Cope
Promentum indistinct; ninth pair of legs of male with two joints and no claw
Conotyla Cook & Collins
(*Craspedosoma* Leach (part))
(*Scotherpes* Cope (part))

15. Eyes with thirteen ocelli; antennae rather stout; ninth pair of legs of male two-jointed
Underwoodia Cook & Collins
Eyes with twenty-five to twenty-seven ocelli; antennae very slender; ninth pair of legs of male five-jointed 16.

16. Length about three-eighths of an inch; promentum indistinct
Batropus Cook & Collins
Length from one-half to slightly over three-quarters of an inch; promentum triangular
Cleidogona Cook & Collins
(*Campodes* Koch)

17. Sternites (ventral plates) after the seventh free from the pleurites (lateral plates); only the first pair of legs on the seventh segment of the male copulatory
Callipodidae, Callipus Risso
(*Lysiopetalum* Brandt)
Sternites after the seventh usually fused with the pleurites; both pairs of legs on the seventh segment of the male copulatory *Julidae* 18.

18. First four segments with legs
Spirobolus Brandt
Legs absent on the third or on the fourth segment 19.

19. Legs absent on the fourth segment 20.
Legs absent on the third segment 21.

20. Ocelli in several rows
Nannolene Bollman
Ocelli in one row
Cambala Gray

21. With couplatory legs on the seventh segment of the male 22.
Copulatory legs hidden 23.

22. Eyes with forty to sixty ocelli
Parajulus Humbert & Saussure
Eyes with eight to ten ocelli
Nopoiulus Menge
(*Nemasoma* Koch)

23. Segments thirty to thirty-five; color yellowish, with a dark mid-dorsal band

Brachyiulus Berlese

(*Julus* Linn. (part))

Segments thirty-five to sixty; color brownish to whitish or light mottled; with a dark band between the eyes 24.

24. With thirty-five to forty-two segments

Diploiulus Berlese

(*Julus* Linn. (part))

With forty-nine to sixty segments

Ophyiulus Berlese

(*Julus* Linn. (part))

KEY TO THE COMMON GENERA OF CHILOPODA OR CENTIPEDES

1. With fifteen pairs of legs 2.

With twenty-one or more pairs of legs in the adult 11.

2. With eight dorsal plates; legs very long

Scutigeromorpha, Scutigera Lamarck

With fifteen leg-bearing segments; legs short *Lithobiomorpha* (*or Lithobiidae*) 3.

3. With one ocellus or with none

Lamyctes Meinert

(*Henicops* Newport)

Eyes with many ocelli 4.

4. Coxal pores numerous, in three to five series; mostly west of the Rockies

Bothropolys Wood

(*Eulithobius* Stuxberg)

Coxal pores not in several series 5.

5. No articular spines on legs; southeastern states

Watobius Chamberlin

Legs with articular spines 6.

6. Spines of one gonopod (foot of male modified for copulation) at an angle with the spines of the other, when viewed from the rear; southern states 7.

Spines of both gonopods of a pair in the same horizontal plane; more generally distributed 8.

7. Antennae twenty-segmented

Arenobius Chamberlin

Antennae with more than twenty segments

Gosibius Chamberlin

8. Angles of dorsal plates not produced posteriorly

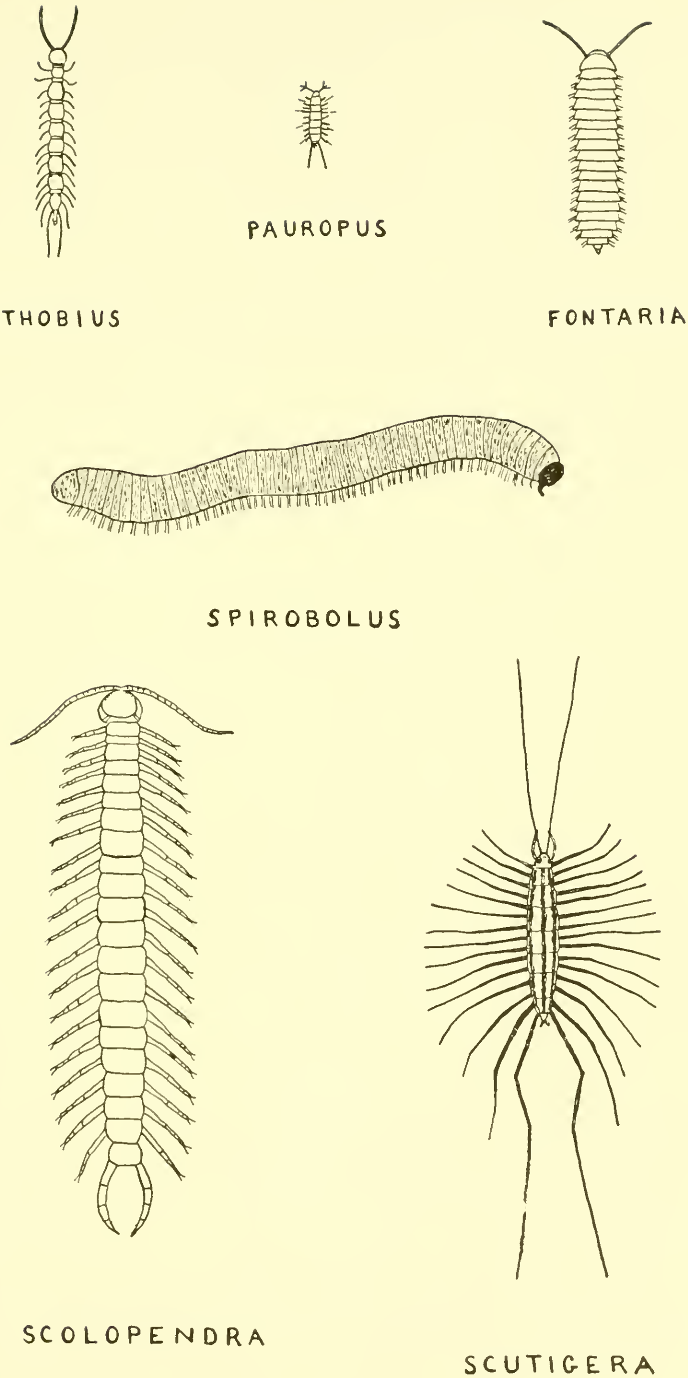
Archilithobius Stuxberg

Posterior angles of a few dorsal plates produced 9.

9. Posterior angles of four dorsal plates produced (7, 9, 11 & 13)

Neolithobius Stuxberg

Posterior angles of two or three dorsal plates produced 10.


PAUROPUS
LITHOBIUS
FONTARIA
SPIROBOLUS
SCOLOPENDRA
SCUTIGERA

MYRIAPODS

10. Posterior angles of two dorsal plates produced (11 & 13)
Hemilithobius Stuxberg
Posterior angles of three dorsal plates produced (9, 11 & 13)
Lithobius Leach

11. With twenty-one to twenty-three pairs of legs; with or without eyes — *Scolopendromorpha* (or *Scolopendridae*) 12.
With thirty-one or more pairs of legs in the adult; without eyes — *Geophilomorpha* (or *Geophilidae*) 15.

12. With eyes (four ocelli)
Scolopendra Linn.
Eyes absent or with only one ocellus 13.

13. With twenty-three pairs of legs
Otocryptops Haase
(*Scolopocryptops* Newport)
With twenty-one pairs of legs 14.

14. Anal legs much shortened and thickened
Theatops Newport
Anal legs longer
Cryptops Leach

15. Dorsal plates not furrowed 16.
Dorsal plates with two lengthwise furrows 17.

16. Head plate narrowed anteriorly
Linotaenia Koch
Head plate narrowed posteriorly
Dicellophilus Cook

17. Ventral pores scattered
Gnathomerium Ribaut
Ventral pores in definite clusters on the ventral plates, or absent 18.

18. Ventral pores on the middle of the ventral plates, or absent 19.
Ventral pores on the rear of the ventral plates 20.

19. No ventral pores
Escaryus Cook & Collins
With ventral pores on the center of the ventral plates
Schendyla Bergs.

20. Last ventral plate narrow
Pachymerium Koch
Last ventral plate usually wide 21.

21. With prehensile feet extending beyond the head
Arenophilus Chamberlin
Prehensile feet not extending beyond the head
Geophilus Leach

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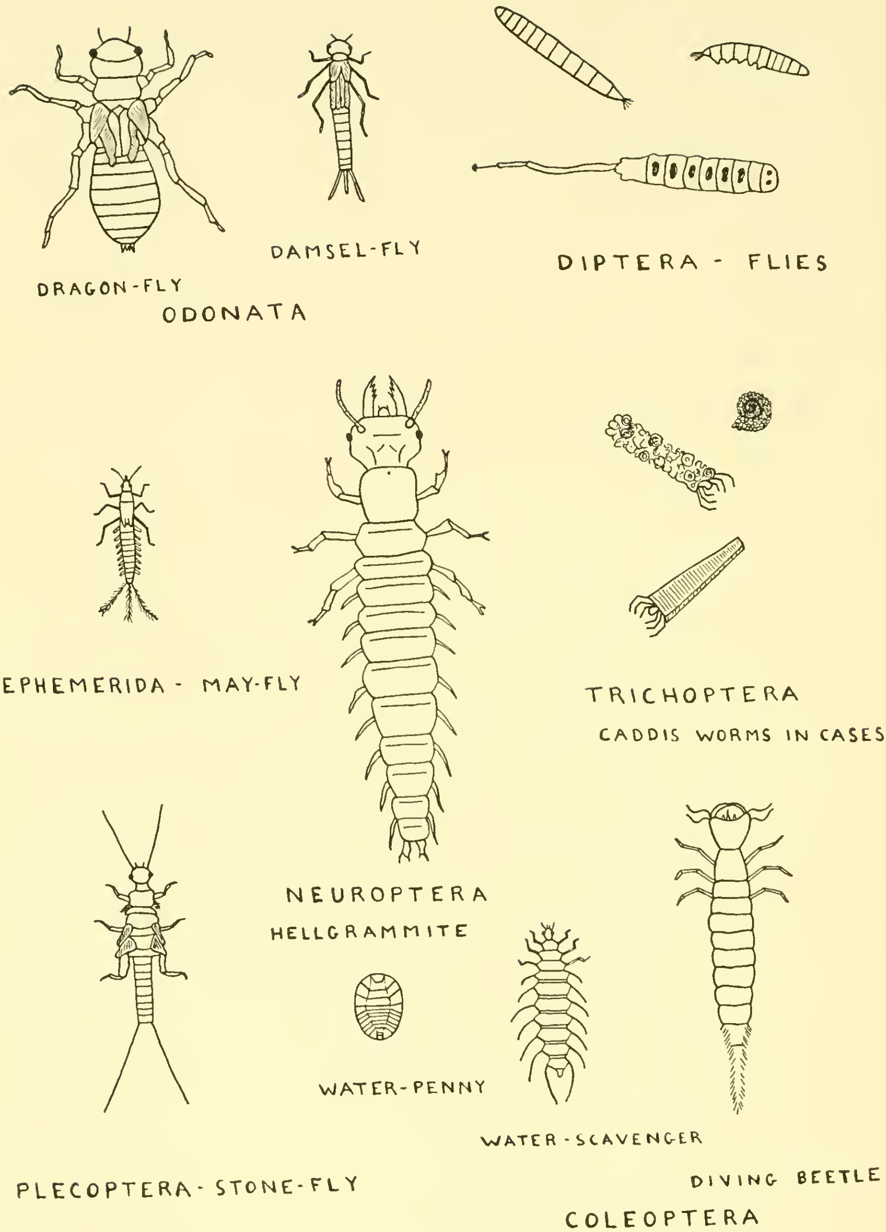
INSECTS

The *Insecta* comprise the largest single group of the animal kingdom, probably possessing more species than all the other groups together. They are also unique in their very wide distribution, being found wherever life is possible, from mountain tops to subterranean caves and from the smallest ponds to the greatest oceans. As might be expected of such a large and widely distributed group, there is great diversity of size and form. As one entomologist has written, some adult insects are smaller than the largest protozoans and some are larger than the smallest mammals. In regard to form we find some with two pairs of wings, some with one pair, and some with no wings at all. The only character at all constant in adult insects is the presence of six legs, so that the name *Hexapoda* is frequently applied to them. Even this distinction fails when we consider larval forms, however, and identification is often extremely difficult.

The *Insecta* are of very great economic importance. A few, like the bee and the silkworm, are of obvious benefit to man, who robs them to obtain food and clothing for himself. Bees and many other insects play a most important part in the economy of nature by carrying pollen from flower to flower, and so enable plants to produce seeds. The bright colors of many flowers, as well as their perfume, are adaptations to attract insects, and similarly remarkable adaptations have developed in the insects. The reader is referred to Charles Darwin's book, *On the Various Contrivances by which Orchids are Fertilized by Insects,* for a classic and scholarly account of these relationships.



IMMATURE WATER INSECTS

On the other hand, many of the insects are harmful or dangerous enemies of man. Some are carriers or spreaders of diseases, such as malaria and typhoid, and some destroy crops. It has been estimated that the American farmer each year loses one-tenth of his crops to insect pests, and in occasional outbreaks, such as those of grasshoppers or chinchbugs, entire crops may be destroyed over large areas. The damage done to property by such insects as clothes-moths, carpet-beetles and termites is too well known to warrant discussion.

Because of the immense numbers of insects, their universal distribution, and the economic importance of many forms the study of insects, or Entomology, has developed into practically a science of its own. For this reason we do not attempt any but the most general discussion or keying of them here. Any of the standard entomologies can be used for a more comprehensive knowledge of this group. These books usually refer to more technical works for specialized study.

The development of insects is an interesting subject for study. A few, like the silver-fish and springtails, undergo no marked changes as they grow. Most insects, however, have a complicated metamorphosis, the young of some not even remotely resembling the adults. Forms like the butterfly and the house-fly, which in their early stages are quite unlike the adults, are called *larvae.* Other forms, like the grasshopper and the dragon-fly, in which the young as they grow become more and more like the adults, are called *nymphs* or *naiads.* If each molt leaves the insect more like the adult than its preceding stage, the immature insect is called a *nymph.* In some forms, such as stone-flies, may-flies, dragon-flies and damsel-flies, the immature insect has developed special structures adapting it for an aquatic life, which are lost when the insect becomes mature. In this case the immature insect is called a *naiad.* An insect has a non-living outer coat or exoskeleton, which it must shed periodically in order to grow. The period between each shedding is called an *instar.* The insects that undergo complete metamorphosis, such as butterflies and moths, acquire at about the fifth instar a form quite different from the earlier caterpillar form. In this new condition the insect, now called the *pupa,* takes no food and shows little outward sign of life. The outer skin is called the *chrysalis.* In some cases, especially in some of the moths, the caterpillar, as it prepares for the pupal stage, spins from its salivary glands a covering of silk threads called a *cocoon* and passes the pupal stage within this. Commercial silk is obtained from such a cocoon, spun by the silk-worm, a native of southeastern Asia. Although apparently lifeless, the insect is now undergoing a great transformation. The caterpillar is being rebuilt into a totally different form. The pupal instar may last only a few weeks or it may extend over a winter. When it ends, the pupal skin splits and the insect emerges in the *imago* or adult form.

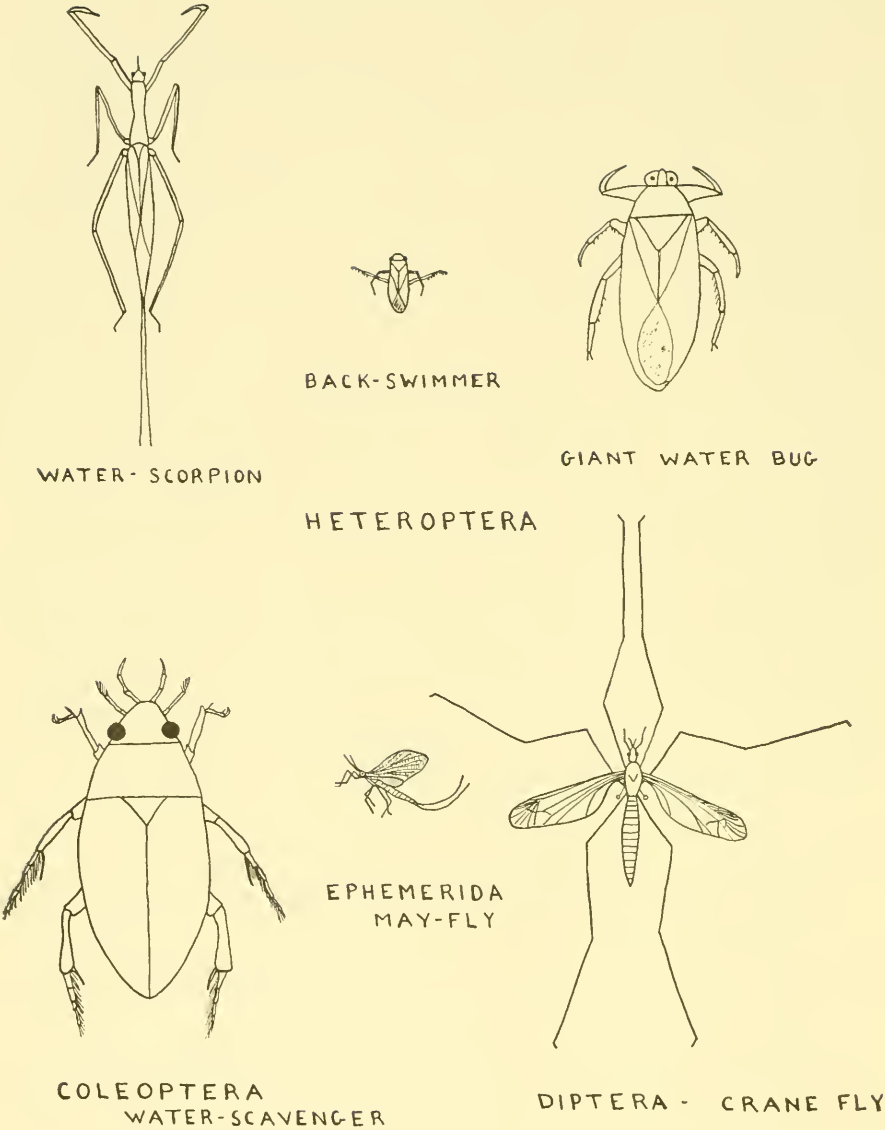
Just as man, largely because of his reasoning ability, is classed at the head of the vertebrates, so the insects, largely because of their extreme development of instinct, are regarded as the highest of the invertebrates. As the final triumph of instinct we find some of the insects organized into complicated communities where each individual plays some definite part in the affairs of the group and specialization and division of labor have reached remarkable heights. In the hive of the honey bee one female, called the queen, does all the egg-laying, while some fifty thousand others carry on all the other activities. The males are known as drones and the females, other than the queen, are called workers. Certain ones act as nurses for the young grubs, others build cells, others act as guards at the hive door, and so on. During the active season each worker serves at some one of these tasks for about two weeks and then devotes the rest of its short life to the main purpose of the hive, the gathering of honey. Only the queen lives for any length of time. If a new egg-laying female is raised, the old queen must fight to the death or leave with her attendants to establish a new home, a procedure known as swarming. Even more complicated but less fully known is the community life of the ant. The ants' use of plant-lice or aphids as "cows" and their constant attendance upon them has been noticed by many a gardener. He may be unaware, however, that the ants commonly take the female aphids into their own nests for the winter, care for their eggs, and establish more aphid colonies each spring. In warmer climates some kinds of ants cut leaves and build mushroom beds upon which they cultivate fungi for food. Certain of the ants regularly keep other species as slaves and may sometimes be seen making furious attacks upon the nests of other species in order to carry off larvae or pupae which may be reared to serve them. Even more elaborate is the community life of the termites, miscalled white ants. In their nests may be found several distinct forms, each serving a different purpose in the activity of the group. There are usually four or more of these "castes". Unlike the bees and the ants, each caste of termites contains both males and females. The harmonious adjustments of these social insects have long excited the attention, admiration and even the envy of man. The reader will find some of the popular accounts of insect life as entertaining as any books of adventure.

Insects in general are considered to be terrestrial animals, but a great many of them are secondarily adapted for the water, especially in the immature stages. Because of their very great numbers, wide distribution and diversity of form they provide excellent material for the study of ecology. In fact many ecology courses deal almost exclusively with insect distribution, abundance and adaptation. Insects are so sensitive to changes in environment, such as light, temperature and the like, that many serve as ecological indicators. The rapidity of chirping of the cricket, for example, is said to be directly correlated with temperature.

The person interested in insects should have no difficulty in finding specimens, even in his own home and garden. During a summer evening a light on an unscreened porch will attract almost innumerable forms. In the daytime a sweep net can be swished back and forth through grass, bushes and other vegetation to gather many small terrestrial forms. In the ponds one can find insects running on the surface, swimming in the water, or crawling in the ooze on the bottom. Most of these aquatic forms can be collected by means of the common dip-net. Insects can be killed by the use of a prepared cyanide bottle or by a wide-mouthed bottle containing a little blotting paper saturated with carbon disulphide or tetrachloride. Large insects, such as beetles, butterflies and moths, can be quickly killed by a drop or two of gasoline put on the abdomen of each by means of a small oil can. Most insects can be preserved dry, speared on non-rusting pins especially made for the purpose. Most entomology texts and handbooks give information concerning the proper way to mount, pin and label insect collections. Butterflies and moths can seldom be caught in perfect condition and so for collections are best reared in captivity from the caterpillar stage or collected as chrysalides or cocoons and preserved soon after they complete their development. Contrary to popular belief even an expert collector cannot make a fortune gathering butterflies for sale, as many rare and beautiful tropical forms seldom sell for more than four or five dollars apiece. Fleshy forms like caterpillars can be preserved dry only after rather difficult preparation, but can be preserved in a solution of one hundred parts of 95% alcohol to ten parts of glycerine. Almost all the other forms of insects, except butterflies and moths, can be so preserved and will remain sufficiently flexible so that, if desired, they can later be pinned out and dried.

KEY TO THE PRINCIPAL ORDERS OF INSECTS

1. Animal with functional wings (sometimes the outer pair are hard and leathery or horny, concealing and protecting the second pair when the animal is at rest) 2.
   Animal without functional wings 25.
2. With one pair of transparent wings, the second pair being represented by minute knobbed structures called balancers or halteres
   Diptera Flies
   With two pairs of wings, the second pair sometimes completely covered by the first 3.
3. First pair of wings horny or leathery and completely covering the second pair when the animal is at rest 4.
   First pair of wings not horny or leathery, or else not completely covering the second pair 8.
4. Front pair of wings thick at base, membranous and overlapping at tips
   Heteroptera True Bugs
   (*Hemiptera* (part))



ADULT WATER INSECTS

Front wings of about the same thickness throughout, not overlapping at tips 5.

5. Front wings horny, not with a network of branching veins 6.
Front wings leathery, with branching veins 7.

6. With large structures resembling a pair of pinchers on the posterior end of the body
Dermaptera Earwigs
Without such pinchers
Coleoptera Beetles

7. Animal with a sucking beak on under side of head and usually folded against the body
Heteroptera True Bugs
(*Hemiptera* (part))
Animal with definite chewing mouth parts
Orthoptera Grasshoppers, Crickets, etc. 35.

8. Very small, usually not over one-quarter of an inch; foot ending in a rounded knob
Thysanoptera Thrips
Larger; foot ending in one or more hooks 9.

9. Wings at least partly shingled with minute scales 10.
Wings not so shingled; network of veins visible 12.

10. Largely nocturnal fliers; wings spread horizontally or folded roof-like on abdomen when at rest; antennae usually feather-like
Lepidoptera (part) Moths
Largely diurnal fliers; wings folded together in vertical position over back when at rest; antennae thread-like and usually knobbed or club shaped at tip 11.

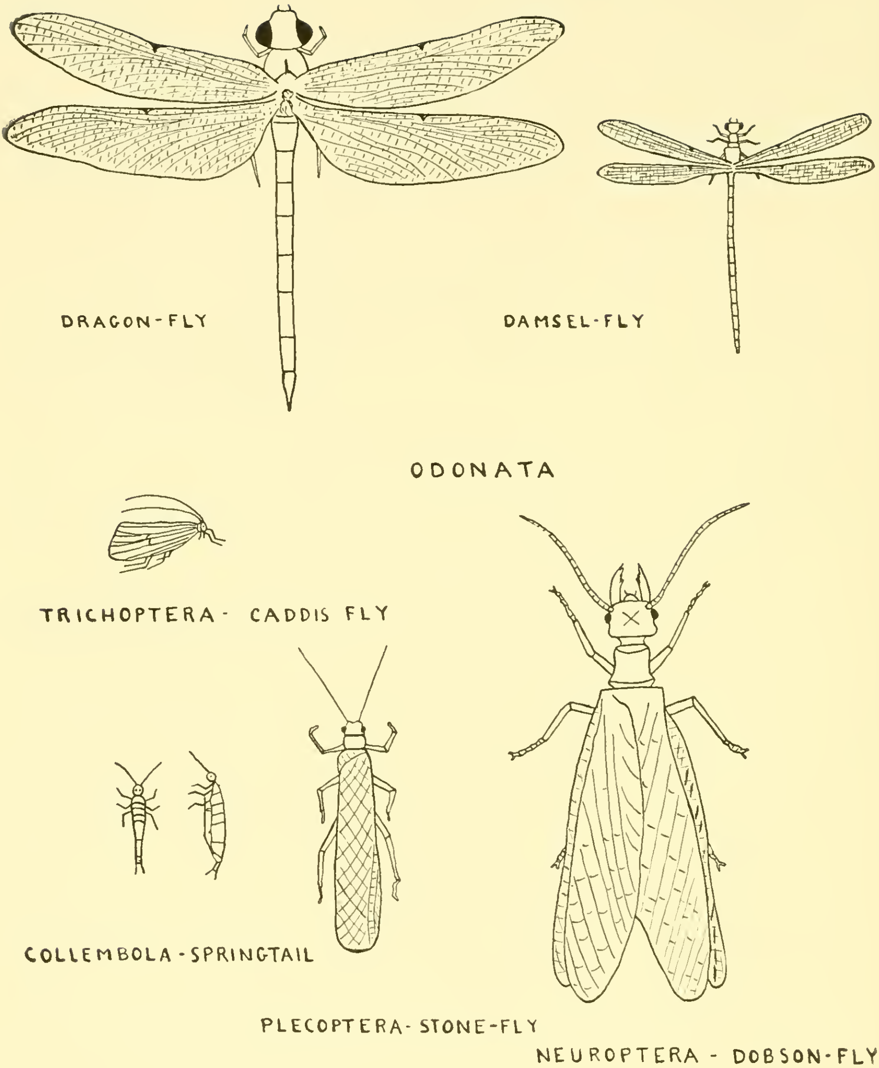
11. Club on antennae partly or completely recurved
Lepidoptera (part), *Hesperidae* Skippers
Club, if present, not recurved
Lepidoptera (part) Butterflies

12. With a piercing or sucking beak on underside of head, and not bee- or fly-like
Homoptera Cicadas, Leaf-hoppers, Aphids, etc.
(*Hemiptera* (part))
With chewing or lapping mouth parts, or else definitely bee- or fly-like 13.

13. Wings each with not more than seven long veins, and with the front wings larger than the back wings; mouth parts evident 14.
Wings with more long veins, or else with back wings not smaller than the front wings 15.

14. Very small, seldom over $\frac{1}{8}''$; wings held against sides so as to form a steep roof over the back
Corrodentia, Psocidae Psocid Flies
Larger; wings usually laid flat on back
Hymenoptera Bees, Wasps, Ants, Saw-flies, etc.

15. Wings with few cross veins 16.
Wings with many cross veins 17.



ADULT WATER INSECTS

16. Hind wings folded like a fan
Orthoptera, Gryllidae Crickets
Wings not so folded; mouth parts not evident
Trichoptera Caddis or Trout Flies

17. With two or three, long, thread-like filaments extending from end of body and with wings held up vertically
Ephemerida May-flies
(*Plectoptera*)
Without such long filaments 18.

18. Not fly-like; body wide and much flattened
Orthoptera, Blattidae Cockroaches, Croton-bugs
Fly-like; body little, if at all, flattened 19.

19. Head lengthened to form a beak-like structure bearing biting mouth parts at the tips
Mecoptera Scorpion Flies
Without such a trunk 20.

20. Antennae very short; wings long and narrow and with an apparent joint near the middle of the front edge 21.
Antennae easily seen; wings without such joint 22.

21. Wings held horizontally when at rest; hind wings larger than the front wings
Odonata, Anisoptera Dragon-flies
Wings held parallel with abdomen, or uptilted; fore and hind wings almost equal
Odonata, Zygoptera Damsel-flies

22. Body very long and slender; antennae enlarged at tips
Neuroptera, Myrmelionidae Ant-lions
Body not extremely slender; antennae not enlarged at tips 23.

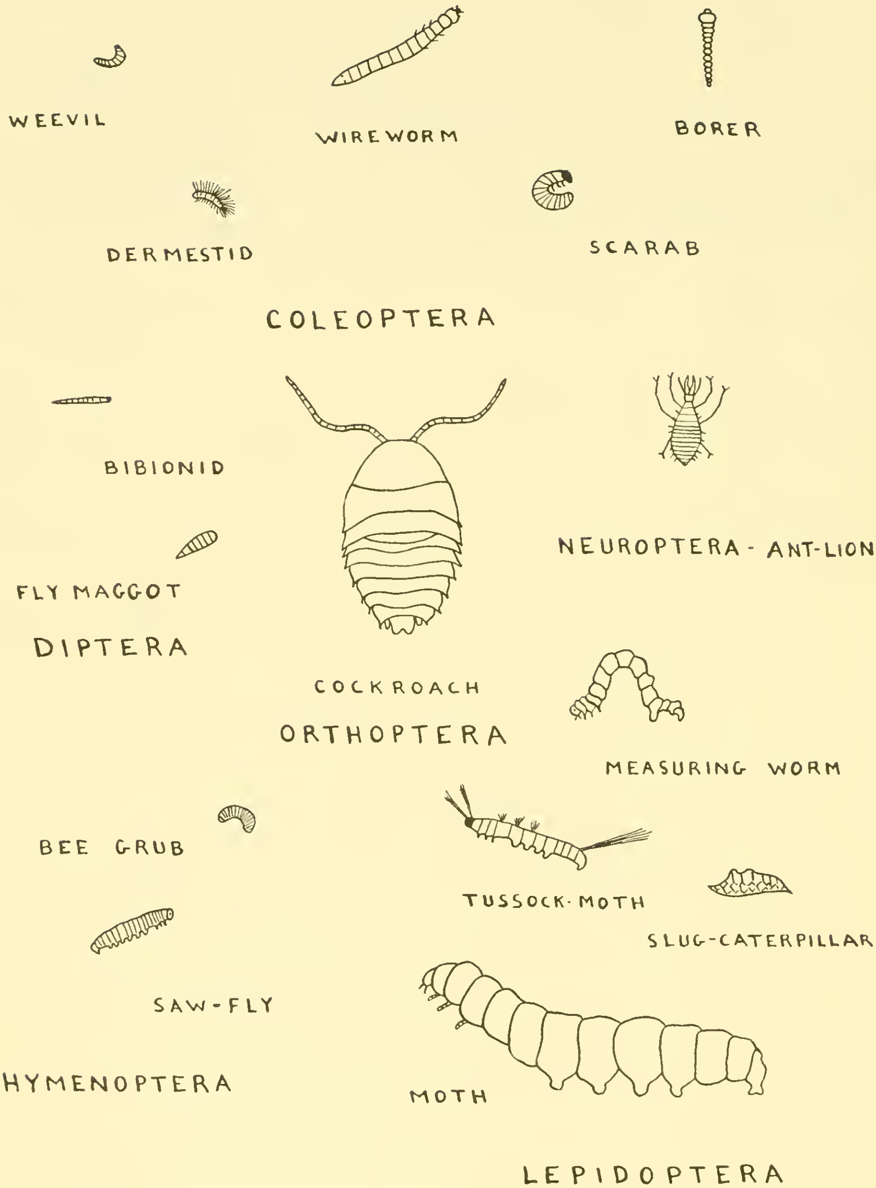
23. Tarsus (end section) of last leg with five segments
Neuroptera Lace-wings, Dobson Flies or Corydalus
Tarsus of hind leg with less than five segments 24.

24. Thorax before wings about as wide as long; wings clear, with distinct veins
Plecoptera Stone-flies
Thorax before wings short, much wider than long; wings whitish, with indistinct veins
Isoptera Termites or "White Ants"

25. With rudimentary or vestigial wings 26.
With no indications of wings 39.

26. With large structures resembling a pair of pinchers at the posterior end of the body
Dermaptera Earwigs
Without such structures 27.

27. Living in water 28.
Living on land 32.



IMMATURE LAND INSECTS

28. No thread-, leaf- or feather-like structures along sides or at the posterior end 29.
With thread-, leaf- or feather-like structures along the sides or at the posterior end of the body 30.

29. With a hinged lower lip that can be extended considerably beyond the head
Odonata, Anisoptera Dragon-fly naiads
Without such a lip
Heteroptera Water Bug nymphs
(*Hemiptera* (part))

30. Without tufts on sides; usually with three, flat, leaf-like "tails" at end of abdomen
Odonata, Zygoptera Damsel-fly naiads
With hair-like or feather-like tufts along the sides 31.

31. With tufts of hair-like filaments behind each leg but with none on the abdomen; "tails" two
Plecoptera Stone-fly naiads
With such tufts along the sides of abdomen; usually with three "tails"
Ephemerida May-fly naiads
(*Plectoptera*)

32. With mouth parts obviously designing for chewing 33.
With sucking beak 38.

33. Not over one-quarter of an inch, usually much smaller; no cross veins in wings: feeding on lichens and fungi
Corrodentia Psocid Flies
Usually much larger; with cross-veined or tough front wings or wing pads 34.

34. With veinless wing covers; hind legs built for running
Coleoptera Beetles (A few forms with degenerate wings)
With net-veined wing covers; usually with hind legs built for jumping or with the front legs greatly modified 35.

35. Hind legs adapted for jumping
Orthoptera (part) Grasshoppers and Crickets
Not so 36.

36. Legs not specialized; body wide and flat
Orthoptera (part) Cockroaches, Croton-bugs
Front legs greatly modified 37.

37. Front legs short and wide, specialized for digging
Orthoptera (part) Mole-crickets
Front legs long and held aloft, specialized for grasping prey
Orthoptera (part) Praying Mantes

38. Beak arising from lower front part of head
Heteroptera True Bugs
(*Hemiptera* (part))
Beak rising from lower back part of head
Homoptera Cicadas, Leaf-hoppers, Aphids

39. Animal caterpillar-like (body more or less cylindrical) 40.
Animal not so worm- or caterpillar-like 53.

40. Living in water 41.
Living on land 44.

41. No legs present
Diptera Fly larvae, Maggots
Legs present 42.

42. Usually found within a case made of sticks, sand or leaf fragments
Trichoptera Caddis worms
Not in such a case 43.

43. Body rather stout, slightly wider anteriorly; getting to be about three-quarters of an inch to three inches long
Neuroptera, Sialidae Alder Flies, Hellgrammite, Dobson or Corydalus
Body usually more slender, usually tapering in the neck region; usually smaller
Coleoptera Water Beetle larvae

44. No definite head 45.
With a definite head 47.

45. In a small cell, usually of wax or mud, and often provided with pollen or insects for food
Hymenoptera Bee and Wasp grubs
Not in such a cell 46.

46. Slug-like, dark-colored, or with tufts of spines; feeding on leaves
Lepidoptera, Eucliidae Slug-caterpillars
White or light colored; usually feeding on dead animal material
Diptera Fly Maggots

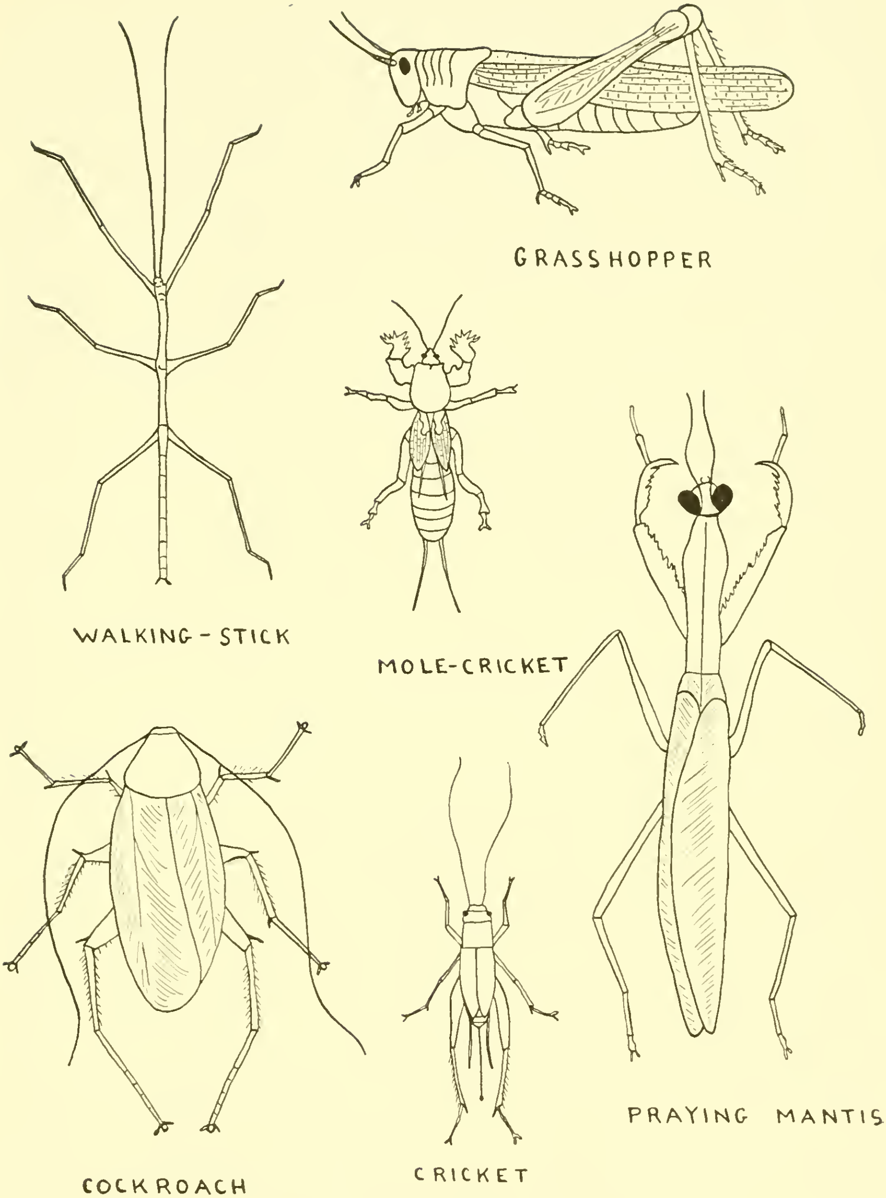
47. With legs on abdominal region 48.
Without any abdominal legs or leg-like processes, except sometimes on the last segment 49.

48. Not more than five pairs of abdominal legs, each usually ending in many minute hooks
Lepidoptera Butterfly or Moth Caterpillars
Six or more pairs of abdominal legs, without hooks
Hymenoptera Sawfly Caterpillars

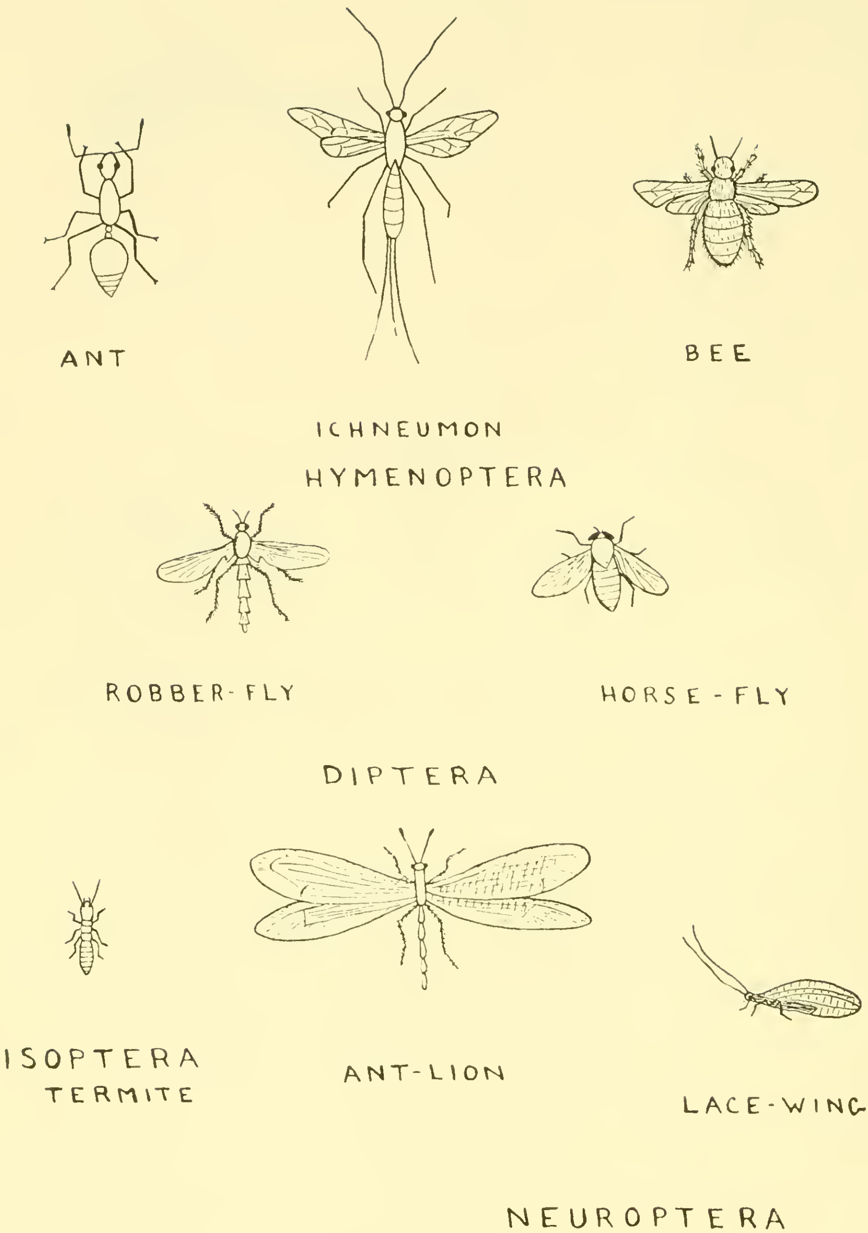
49. With legs on the thoracic region
Coleoptera Beetle Grubs
Without thoracic legs 50.

50. Animal minute, but with definite biting mouth parts, and not with a black head
Siphonaptera Flea larvae
(*Suctoria*)
Not minute, or else with blackish head 51.

51. Small, slender, usually pointed at posterior end; head blackish
Diptera Fly Maggots
Up to two inches in length; head not especially evident 52.



ORTHOPTERA
ADULT LAND INSECTS



ADULT LAND INSECTS

52. Thorax thick and muscular; animal usually living in wood
Coleoptera Borer Beetle Grubs
Body soft and stout; animal usually living in nuts, fruits, or seeds
Coleoptera Weevil Grubs

53. Animal with little or no powers of locomotion; living on plants; scale-like or covered with a cottony or mealy secretion
Homoptera, Coccidae Scale Insects, Mealy Bugs, Bark Lice
Animal not so 54.

54. Animal minute; abdomen of not more than six segments and bearing on the end a pair of appendages which are usually folded under the body and enable the animal to jump
Collembola Springtails
Animal not so 55.

55. Living in water 56.
Living on land 63.

56. Back extended to form a flattened oval shield which extends over and hides the rest of the animal
Coleoptera, Psephenidae and *Dryopidae* larvae Water-pennies
Not so 57.

57. Mouth parts forming a sucking tube 58.
Not so 59.

58. Parasitic in fresh-water sponges
Neuroptera, Sisyridae Sponge-fly larvae
Not so
Heteroptera True Bug nymphs
(*Hemiptera* (part))

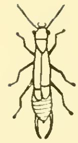
59. With a hinged lower lip that can be extended considerably beyond the head 60.
Not so 61.

60. No tail-like processes from the end of the abdomen
Odonata, Anisoptera Dragon-fly naiads
Usually with three, flat, leaf-like "tails"
Odonata, Zygoptera Damsel-fly naiads

61. With sickle shaped mandibles (appearing like a pair of pinchers or tongs) adapted for sucking; usually without "tails"
Coleoptera Water Beetle larvae
With biting or chewing mouth parts; usually with two or three "tails" 62.

62. With tufts of hair-like filaments behind each leg but with none on the abdomen; "tails" two
Plecoptera Stone-fly naiads
With tufts along sides of abdomen; usually with three "tails"
Ephemerida May-fly naiads
(*Plectoptera*)

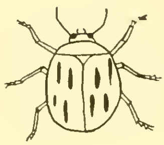
63. Very small and much flattened laterally; jumping; parasitic on warm-blooded animals.
Siphonaptera Fleas
(*Suctoria*)



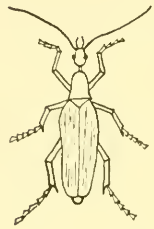
DERMAPTERA - EARWIG

THYSANURA - SILVER-FISH

THYSANOPTERA - THRIP

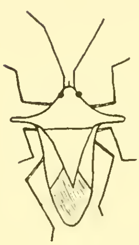


POTATO BEETLE

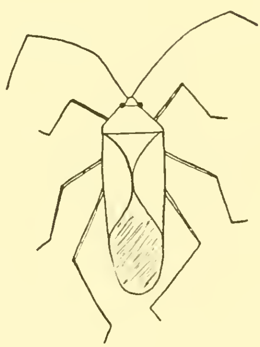


GROUND BEETLE

COLEOPTERA



STINK-BUG



SQUASH-BUG

BEDBUG

HETEROPTERA

ADULT LAND INSECTS

Not much flattened laterally or over one-quarter of an inch in length 64.

64. Minute, soft and whitish; found in old books and papers
Corrodentia Book-lice
Not so 65.

65. Body much flattened dorso-ventrally 66.
Body more circular in cross section 70.

66. With large structures resembling a pair of pinchers on the posterior end of the body
Dermaptera Earwigs
Not so 67.

67. Antennae long, from one-third to equal to the length of the body; with two or three, long, jointed, tail-like processes on the posterior end; not parasitic on animals
Thysanura Silver-fish or Bristle-tails
Antennae very short; no long, jointed, caudal appendages; parasitic on birds or mammals 68.

68. With biting mouth parts; parasitic mostly on birds, a few species on mammals
Mallophaga Bird Lice or Biting Lice
With sucking mouth parts; on mammals 69.

69. Tarsus (last section of foot) with three segments, and ending in two hooks
Heteroptera, Cimicidae Bedbugs
(*Hemiptera* (part))
Tarsus with one segment and ending in a single hook which opposes a projection from the tibia or section above
Siphunculata True Lice
(*Anoplura*)

70. Parasitic on birds and mammals; antennae short 71.
Not parasitic on animals; antennae long or short 72.

71. With biting mouth parts; common on birds, occasional on mammals
Mallophaga Bird Lice or Biting Lice
With sucking mouth parts; common on mammals
Siphunculata True Lice
(*Anoplura*)

72. Body thickly coated with small scales or hairs 73.
No thick coat of scales or hairs 74.

73. Very small; usually found in groups; with beak-like sucking mouth parts
Homoptera, Aphididae Woolly Aphids
Usually about ½″ long; rarely in groups; mouth parts not evident
Lepidoptera, Liparidae and *Geometridae* (part)
Female Tussock-moth, Female Canker-worm Moths

74. With a pair of prominent, pincher-like mouth parts as long as, or longer than, the head
Neuroptera Ant-lion, Aphis-lion
Not so 75.

75. With beak-like, piercing and sucking mouth parts; not ant-like 76.
With biting and chewing mouth parts; may or may not be ant-like 77.

76. Beak arising from back of lower side of head
Homoptera Cicada, Tree and Leaf Hoppers, Frog-spit, Aphids
(*Hemiptera* (part))
Beak arising from front side of lower part of head
Heteroptera True Bugs
(*Hemiptera* (part))

77. Body narrow and elongated; legs long, about one-half as long as the body
Orthoptera, Phasmidae and *Mantidae*
Walking-sticks and Praying Mantes
Body not markedly elongate; legs long or short 78.

78. Hind leg long and specialized for jumping, or else with the front legs very short and stout and modified for digging 79.
Neither hind nor front legs showing any marked specialization 80.

79. Jumping animals
Orthoptera; Acrididae, Tettigoniidae and *Gryllidae*
Grasshoppers and Crickets
Digging animals
Orthoptera; Gryllidae (part), *Gryllotalpinae* Mole-crickets

80. Not ant-like; no narrow "waist"; color not yellowish or very light brown
Coleoptera Beetles
Ant-like; either with a very narrow "waist" or else yellowish or very light brown in color 81.

81. No marked "waist"; antennae not abruptly bent; color yellowish or very light brown
Isoptera Termites, "White Ants"
With a very narow "waist" or constriction of the anterior part of the abdomen; antennae usually with an abrupt bend 82.

82. With an upturned ridge or knob on "waist"; never hairy
Hymenoptera, Formicidae True Ants
No knob or ridge on "waist"; sometimes covered with velvety hairs; sometimes with red and yellow markings
Hymenoptera, Mutillidae Velvet Ants

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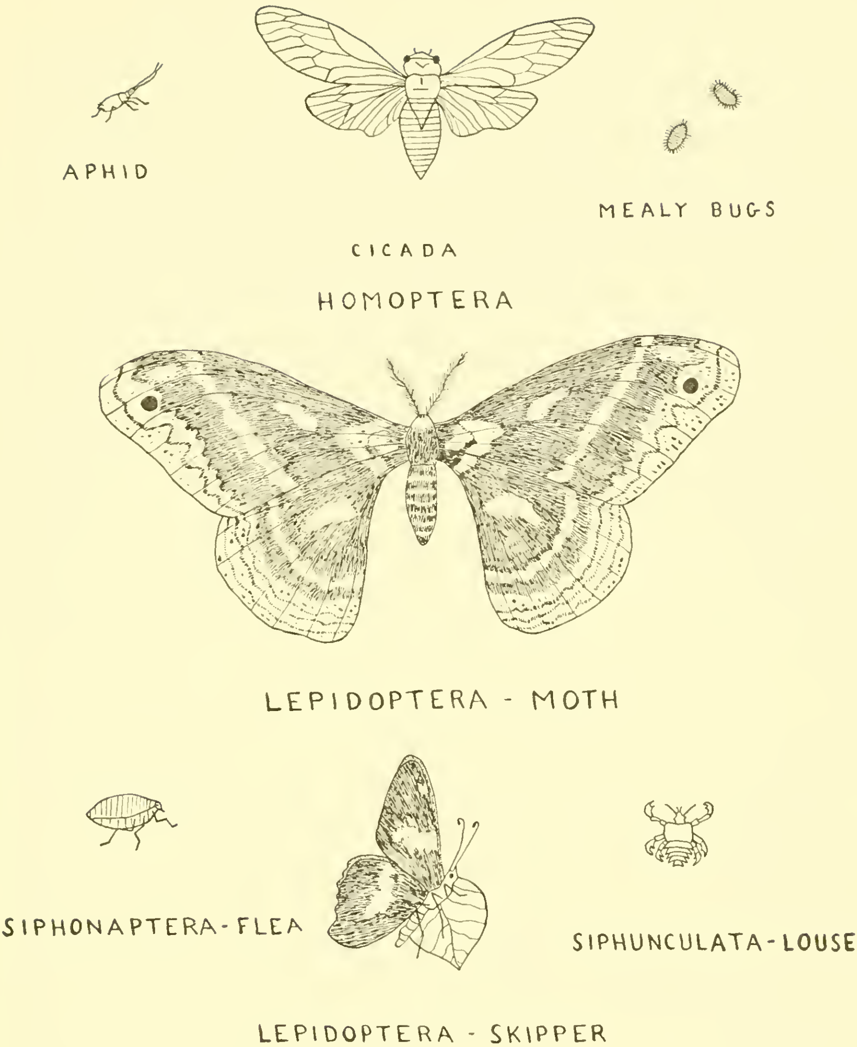

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FRESH-WATER FISHES

CHAPTER 8

The fishes rival the birds and the mammals in popular appeal and comprise one of the three major groups of the animal kingdom generally affected by the game laws. The sale of fishing equipment each year is enormous, and sporting books and magazines devote countless pages to discussions of the paraphernalia and technique of the angler. The familiar game fishes, however, make up only a small proportion of American fresh-water fishes. The recent popularity of home and public aquaria has created a fancy for other interesting or beautiful species. Although the popular tropicals come from Central and South America, several of the forms commonly sold in pet shops are native to the southern states. It is a surprise to many people to learn that there are also many attractive and interesting small fishes in northern ponds and rivers.

Not true fishes but related to them are the lampreys, frequently called lamprey-eels. As a matter of fact the eel is a true fish which, by the loss of some structures, has come to resemble the lamprey slightly. The latter can be distinguished from eels and all other fishes by a row of gill openings on each side, its lack of paired fins and its jawless, and usually round, mouth. From this round mouth is derived the scientific name of the group to which it belongs, the *Cyclostomes.* All lampreys start their lives in fresh water, hatching from eggs their parents have deposited and covered with sand or gravel in nests in the river or lake bed. Lampreys have a larval stage, called the *ammocoete,* corresponding somewhat to the tadpole stage of the frog. The external differences between larvae and adults are not very marked, but the differences in internal anatomy are great. The chief external difference lies in the mouth region, the larva having a pair of lips overhung by a hood as wide as the body. In the adult the hood is gone and so are the lips, only a circular depression, which becomes armed with epidermal "teeth", remaining. Few people besides the fishermen who gather them for bait ever see the larval lampreys, for they live concealed in burrows in the sand or gravel and feed on minute organisms which the water brings to them. Two or more years are passed in this secluded existence before the animals transform into adults. It is known that some species are unable to feed as adults, living on material stored in their tissues until they reproduce. Others prey on fish and may live for several years as adults before reproducing. With the disc-like structure around the mouth acting as a suction cup, the parasitic lamprey attaches itself to a fish, rasps a hole in the body wall by means of its epidermal teeth, and sucks its fill of blood. A special secretion from buccal or mouth glands keeps the blood from clotting until the lamprey has finished its meal — a development also found in the blood-sucking leeches. Once satisfied, the lamprey leaves its host, attaches itself to a rock and digests its meal before it again attacks a fish. The sea lampreys swim up the rivers to spawn in fresh water. Some of the lampreys develop spectacular orange coloring at spawning time, but this is not constant, as some dark and some brightly colored individuals may be seen in the same run, and some years very few colored ones are to be found. It seems probable that none of the adults of any species survive the spawning period, as the digestive tract is almost completely degenerated and there is no trace of any second crop of eggs. It is possible to collect larval lampreys from suitable gravel bars in lakes or rivers, by means of a wire strainer, and those about to transform will live for some time in a shaded aquarium.

One group of fishes appeals to the layman because of its peculiarities and to the scientist because of the light it throws on taxonomic and evolutionary problems. The species of this group have heterocercal tails and a number of internal anatomical pecularities which place them as primitive fishes, intermediate between sharks and the true bony fishes. Here we find the gars, widely distributed fishes with long, almost cylindrical bodies and peculiar, diamond-shaped scales, so hard as to lead the pioneer naturalist, Rafinesque, to state that they would turn a musket ball. A long mouth, resembling a duck's or a heron's beak but full of needle-like teeth, completes the pirate's make-up. Another odd fish is known, because of its huge spatulate snout, as the paddlefish or spoon-bill. This species was formerly very common, and is still fairly abundant, in the Mississippi River and its larger tributaries. It has an inferior mouth like that of a shark, soft flaps for gill covers, and no evident scales. Although it may reach a length of six feet and a weight of one hundred and fifty pounds, it lives almost entirely on microscopic organisms, and is supposed to use its huge paddle as a spoon to stir up and concentrate these minute morsels. A very similar fish, probably its only living near relative, is found in the Yangtse River in China. A third division of this group of primitive fishes contains the sturgeons, which have reduced the number of their scales and fused some to form huge, bony dermal plates. These plates usually lie in rows on each side, so that protection is obtained without the sacrifice of flexibility. As the sturgeon matures, it often loses these bony shields. Some species become five or six feet long. Mature female sturgeons are highly prized for the roe, which is known as caviar when properly prepared. The roe of the paddlefish also makes good caviar, but that of the gar, strangely enough, is reported to be toxic. These fishes—gars, paddlefish and sturgeons, together with the bowfin or river dogfish — are often referred to as the *Ganoids,* although only the gars have well developed ganoid scales. They are the survivors of a once very numerous group, well represented in fossil beds.

The largest family of fishes found in the United States is the minnow family, the *Cyprinidae.* The recent check list of fishes records almost three hundred native species. Most of them seldom get to be more than a few inches long, but some of the minnows of the western states, of which the Gila Trout is an example, become a foot or more long. The largest native minnow, *Ptychocheilus lucius,* may attain a length of five feet. Two introduced Asiatic members of the minnow family, the carp and the goldfish, get to be over a foot long. The carp has been generally blamed for the decrease in number of many of our best native fishes, but the truth seems to be that man, by polluting the streams, has himself killed off many native forms, while the hardier carp survives and multiplies. Its habit of grubbing in the mud, however, does result in the uprooting of aquatic vegetation and the destruction of the eggs of some of its rivals. The goldfish often escapes from captivity, and, especially if it has failed to make the change from its original olive gray to the more familiar gold, may escape its enemies and attain a size far greater than that of more closely confined specimens. Minnows are always a bugbear to the amateur, for the differences between the species are not well marked and are often based on pharyngeal teeth and internal characters. Also there are so many species that a reading of the minnow section of the check list is likely to leave one with the impression that every stream, tributary and pond has its own individual species. "Minnows of Michigan", by Hubbs and Cooper, is an excellent introduction to a study of the family and should serve as a model for similar surveys in other states.

Another large family, the suckers or *Catostomidae,* all have extensible sucking mouths, specialized for drawing insects and worms from under stones. Their peculiar method of feeding reminds one of the action of a vacuum cleaner. The fish hovers just in front of its prey, which, drawn by the powerful suction, suddenly appears to leap into the waiting mouth. Some genera of suckers resemble carp quite closely, except for their lips and the absence of a dorsal and an anal spine, and are sometimes sold as "winter carp" in fish markets. Like carp, when taken from cold running waters their flesh is fairly palatable, although the many small bones are a nuisance. In warm waters the flesh becomes soft and oily. Suckers are among the fishes that make spectacular runs up streams during the spawning season. They do a great deal of splashing at the surface at this time, especially over the gravel beds where they drop their eggs. Since the suckers are largely insectivorous they compete with the game fishes for food and so are unpopular with sportsmen and fish culturists.

Another large family, second only to the minnows in number of native species, is that of the darters, the *Etheostomidae,* for which the check list records over a hundred species occurring within the United States, none west of the Rockies. These fishes, having small or no air bladders, cannot float in the water, but lie on the bottom while at rest, and make sudden dashing excursions from place to place. This peculiar movement accounts for their common name. Their large paired fins, both in the thoracic region, give these small fishes a striking appearance. Many of them are beautifully and brilliantly colored. Unfortunately, like most dwellers in swiftly running water, they need an abundance of oxygen and therefore seldom live long in aquaria where we might admire and study them.

A few fishes make long journeys for egg-laying. The Atlantic and the Pacific salmon return from their feeding grounds at sea to deposit their eggs in the headwaters of streams. Studies indicate that some return to the same stream, and even to the same tributary, in which they hatched and from which they migrated three or four years before. The Pacific salmon use all their energy in this migration and die shortly afterwards. The Atlantic salmon apparently survive, return to sea, and live to make more spawning trips in other years. Along our coasts each spring multitudes of shad come hurling themselves into the mouths of fresh-water streams to spawn, often in such numbers that they force one another out of the water in their frenzied leapings. Early settlers along the Atlantic coast were observant enough to notice the coincidence of the spring runs of shad with the flowering of a common native shrub, which they called the shadbush. In recent years power dams have kept the shad from their old spawning grounds in many localities. Shad is still sold commercially, however, and shad roe is considered a delicacy. The fishes which come from salt to fresh water to spawn are called anadromous.

The eel has reversed this process, the females growing to maturity in fresh water but descending streams and going to sea to spawn. They are termed catadromous. As they journey toward the sea their color changes from black to shining white, and they reach the ocean as what the fishermen call "silver eels". Here they join the males, which stay in brackish or salt water, and make a pilgrimage to the South Atlantic, in the region of the Sargasso Sea. The parents do not survive the egg laying. The baby eel is a flattened, ribbon-like creature which, when it was first discovered, was taken for a small, adult, marine fish. After about a year in this stage the American eel becomes more cylindrical, takes to living near the surface, and continually swims toward our coasts. It reaches them when it is only about three inches long. The males usually remain in brackish water, but the females continue their migrations, traveling by night and resting by day, until they distribute themselves all through the streams. The European eel migrates to almost the same breeding grounds as does the American species.

Most fishes lay large numbers of eggs, those of most species being unpigmented, but some, like those of the sturgeon, being colored. A few fishes, *Gambusia,* for example, bring forth living young. The males of many species become more attractive during the breeding season, developing brilliant colors on the body or, as in some of the minnows, pearl organs on the head. Fertilzation is external in most egg-laying forms. If any nest is built or care exercised over the young, it is usually the male that assumes most of the responsibility. Many of the marine fishes lay eggs of the floating or pelagic type. These, being exposed to many dangers, are produced in immense numbers. It is estimated that the average adult codfish produces about nine million eggs at one time. Most of the fresh-water fishes lay eggs of the sinking or demersal type. A fifteen pound carp lays about two million eggs, which are allowed to fall among vegetation, to which they adhere. A salmon of about the same size buries its crop of about 17,000 eggs in the gravel of a stream, where they will be fairly secure from predators and yet be well aerated. Some fishes, such as the sunfishes, clear out circular depressions on the floor of the lake and stand guard over the eggs as they develop. The male will bite vigorously at anything that intrudes, but it is a poor sportsman indeed who will profit by this habit to get a string of fish. A few moments spent in watching the nest will convince the observer that minnows and snails make the job of guard no easy one and that the batch of eggs would have little chance of survival if the gallant defender were removed. The common sunfish produces about 5,000 eggs. Catfishes generally lay their eggs in a hollow sunken log or in a hole in the bank. The male watches over the eggs and later takes the school of young out on excursions as they begin to travel. A few fishes, such as the sticklebacks, build elaborate nests, much like those of birds, among the water weeds. In general, greater parental care in selecting the nesting site or caring for the young compensates for a reduction in the number of eggs, the end result being that each group maintains its numbers in the biotic equilibrium.

Fishes afford good material for the study of biological problems. A few fields of investigation in which our knowledge is still incomplete are suggested here.

Weberian apparatus—comparative studies of its development in different species; tests on its functions.

Air bladder—exchange of gases; gas content under various environmental conditions.

Migration—tagging experiments on (a) random wandering and its relation to natural restocking of areas depleted by temporary pollution or overfishing; (b) directed movements—migration for reproductive purposes or with seasonal changes.

Distribution—limitation of ranges through natural barriers and through failure in adaptation. Recent changes due to intentional introduction or to accidental introduction as bait or by canals and floods.

Species—limits of species, relation to subspecies. Ecological varieties. Natural hybrids.

Growth—determination by scales and otoliths. Correlation of growth rate with environmental conditions—food supply, pollution, limitation of movement by dams, etc. Problems of relative growth and change in proportions.

Life Histories—many forms are still not completely studied.

Conservation—Fishways, their operation and limitations. Stream improvement by construction of small dams and pools to promote aeration and refuges.

Practical basis of legal restrictions—closed seasons, bag limits, size limits, methods of fishing.

Control of native and introduced forms.

Pollution—maximum amount of organic pollution consistent with fish maintenance; industrial wastes.

Hatchery problems—embryology; effect of varying conditions.

Stocking streams—survival of eyed eggs, fingerlings, older fish.

As stated before, classification is dependent upon a complete knowledge of the anatomy, physiology and ecology of the organism. Obviously the beginner must expect to devote much serious study to any group before he can understand the reasons for the assignment of an animal to some special taxonomic postion. Even after an animal has been known and studied for years, some new discovery may necessitate a change in its classification. When experts sometimes fail to agree, the beginner can hardly expect to escape making some errors in the identification of animals. To aid him in the use of the following key and in beginning a study of fish taxonomy the following descriptions and suggestions are offered.

Capturing Fish

Small fishes may be taken with a dip-net, minnow trap or seine. Larger ones may be taken in nets of various types as used by commercial fishermen or, if time permits, by hook and line. The game laws should be checked carefully. Some states require one to take out a fishing license before he may catch or have in his possession a native fish of any kind, even a minnow. Special licenses are often required for the use of seines and other types of nets, and the sizes of mesh and net are limited. Since violators may be fined a certain amount for each fish held illegally, a bucket of minnows might cost one a small fortune.

Preserving Fish

If possible, the live fish should be drowned in strong formalin, and then promptly transferred to 5% formalin for storage. This procedure results in the extension of fins, which is of much help to the student later, when fin-rays may have to be counted and measured. If the fish is large, 10% formalin may be injected, by means of syringe and hypodermic needle, into the body cavity. A penciled or India ink label, giving full particulars of season and place of capture, should always be packed with each group. If several groups are placed in one container, each may be wrapped in cheesecloth and another label tied to each bundle. Colors bleach out under any condition, but more rapidly if the specimens are exposed to light or preserved in alcohol. Improperly cared for specimens which have dried up can be partially restored by soaking them in 2% solution of potassium hydroxide, but close watch must be kept or they will disintegrate or become transparent. They should be thoroughly washed before they are returned to a preservative.

Measurements

Fishermen usually consider the length as the over-all measurement. The scientist measures from the tip of the nose to the root of the tail, the fin portion of the tail not being included. The depth or height is the next most common measurement, being the greatest vertical distance from dorsal—usually the base of the dorsal fin—to the ventral side. These measurements are often expressed as proportions. Thus we might say that the black bass has its depth 3 in length and some of the darters have depth 6 or more in length. The length of the head, from the tip of snout to the back of the stiff part of the operculum, is another useful measurement. The snout is measured from the tip of the head to the front of the eye. Always take actual measurements. Markings and structures create optical illusions, and an estimate is seldom reliable.

The Tail

The ganoid group of fishes has an asymmetrical and primitive type of tail, resembling that of sharks. The vertebral column extends at least slightly into the upper lobe of the tail fin, a condition called heterocercal.

Most of the bony fishes have a superficially symmetrical tail, the homocercal, the end of the backbone being formed by a large bone called the urostyle. Actually, as Louis Agassiz pointed out, this is an extreme development of the heterocercal tail, the end of the vertebral column being turned still further upward, the upper lobe of the tail fin disappearing and the lower lobe spreading to form the apparently complete symmetrical one. This process is recapitulated in the early development of many teleosts. In the Cod family, (*Gadidae*), a truly symmetrical tail known as isocercal has been developed through the loss of the original one and the meeting of parts of the dorsal and anal fins.

The Fins

The fins fall into two categories: the unpaired, consisting of the dorsal and anal; and the paired, which correspond in a general way to the limbs of higher animals. In the more primitive fishes the fins are supported only by rays—soft, segmented, and more or less branched structures. More specialized fishes have also unsegmented and unbranched spines. In technical descriptions the spines are referred to by Roman numerals, the rays by Arabic, so to an ichthyologist

Perca flavescens D. XIII, 14 means that the dorsal fin of the yellow perch usually has thirteen spines and fourteen rays. The spiny portion of the dorsal fin is usually partly, sometimes wholly, separated from the rayed portion. Since the rays are branched, care must be taken to count the bases. In the spiny-finned fishes there are usually spines in the anal, and often in the pectoral, fins. The *Ameiuridae, Salmonidae* and a few other families have an additional dorsal fin, posterior to the rayed one and unsupported, in native species, by any rays or spines. This is called the adipose fin. Sometimes its posterior margin is adnate or joined to the fish's back, in which case the student may overlook it or mistake it for part of the tail fin. Of the paired fins, the position of the pelvics is most helpful in identification. Regardless of their position anterio-posteriorly, they are always more ventral than the pectoral fins, and are sometimes called the ventral fins. It is well to remember this, for in some families, including the cods (*Gadidae*), they are actually anterior to the pectoral fins. This position is described as jugular. If they lie almost directly below the pectorals, as in the darters (*Etheostomidae*) they are said to be thoracic. In the minnow and sucker families (*Cyprinidae* and *Catostomidae*) they are quite posterior and are said to be abdominal in position. In the sticklebacks (*Gasterosteidae*), the pelvic fins are usually almost central, but are called subabdominal.

Lateral Line

The lateral line is the external indication of a complicated sense-organ system of canals covering the head and extending along the sides of the body. Small openings from each canal are usually shown by small openings or tubes in some of the scales. The line so formed may be evident along the whole side and even on the tail, or it may be only partially evident. On some fishes it forms a relatively straight line, while on others it may curve up or down, possibly to avoid water currents produced by the pectoral fins Care must be taken to avoid confusing the lateral line with a pigmented lateral stripe often present.

Scales

The ganoid type of fish scale, a very hard, shining, rhombic one, is now developed among North American fishes only by the gars as a complete covering and by the sturgeons as a small patch on the upper lobe of the tail. Two types of scales are found on the higher fishes. One type, the cycloid, is fairly regularly oval. The other type, the ctenoid, has its free edge toothed. It has been suggested that the type of scale might serve as a basis for classification but, unfortunately for the idea, intermediate forms are found and in one family one may find both types of scales.

The number of scales is often useful as a diagnostic character, and a system of recording has been developed. For example, 8-45-10 means that the fish has 45 scales in the lateral line row or in a line from head to tail, eight rows counted diagonally from the lateral line to the base of the dorsal fin, and ten rows from the lateral line down to the base of the anal fin.

Head

The position of the mouth, terminal, superior or inferior, is important. The bones which normally form the margin of the upper jaw are the premaxillary and the maxillary. These should be carefully located. In some fishes the premaxillary is long and underlies the maxillary, forming the entire margin of the jaw, while in other fishes both bones reach the margin. In some fishes both bones are hinged at the front, free at the back, and, when swung forward, support skin folds to form a tube with which food can be sucked up.

The opercular bones should be located and their names learned. Variations in their shapes and even in their number are found. In the catfish family, *Ameiuridae,* for example, the subopercular is not developed.

Gill Membranes

These are the folds of skin which form the floor of the gill chamber, and which are usually supported by cartilaginous or bony bars called the branchiostegal rays. The membrane from one side may extend almost directly across to, and fuse with, the corresponding one on the other side, or both may extend far forward before joining. The fused membranes may or may not be joined to the isthmus or section of the body directly beneath them.

Teeth

Teeth may be found not only on the jaws but also on the roof of the mouth and on the tongue. Many fishes have teeth on the pharyngeal bones behind the last gill arch, even though they may not have any in the mouth. These pharyngeal teeth are often of great importance in taxonomic work, especially in the minnow family, *Cyprinidae.* The pharyngeal bones may be removed by reaching in under the operculum with small forceps. The bones lie directly behind the gills and correspond to a fifth gill arch. If they are carefully removed, cleaned and dried, the teeth may be examined under a lens. The bones from both sides should be examined, as they are not always alike. The lower pharyngeals are the most highly specialized and most commonly used in identification. The tooth formula is usually given for both members of a pair: thus 4 - 4 means one row of four teeth on the right and left pharyngeals, 2 - 4 - 4 - 1 means that there are two rows on each, the left with two in the outer and four in the inner row, the right with four in the main or inner row and one in the outer row. The nature of the surface of the pharyngeal teeth is also important and gives a clue to the food habits.

Gill Rakers

The gill arches carry, in addition to the double row of gill filaments on the outer side of each, a double row of projections on the inner side. These are called the gill rakers, and apparently serve to keep particles of food or other matter from entering the gill chambers. In the fish-eating fishes the gill rakers are usually very short, in the plankton eaters they are usually numerous and long.

Air Bladder

The air bladder or swim bladder lies in the upper part of the body cavity, usually directly beneath the backbone. In the less specialized teleosts an open duct connects it with the gullet. In the more specialized forms the duct is vestigial or absent, the gases in the air bladder being received from the blood. In either case, the air bladder apparently serves as a reservoir of oxygen which can be withdrawn into the blood and replaced by carbon dioxide or by relatively inert gases such as nitrogen. The air bladder is probably not to be regarded as an ancestral form of lung but as a parallel development. Sharks and lampreys show no indication of it. In the gars and river dogfish it is usually two lobed. In the higher fishes it may be constricted to form an anterior and a posterior chamber. A few fishes, especially those like the darters which have become adapted to life in swift streams, have the air bladder much reduced or absent.

Weberian Apparatus

The characins, minnows, suckers and catfishes have a peculiar modification of the first four vertebrae. These are usually partly fused and sections of them form a linked chain of bones connecting the air bladder with the canals of the inner ear. When first discovered, these bones were regarded as equivalent to the auditory ossicles of the mammalian middle ear, but that has since been disproved. The function of the Weberian apparatus is still uncertain. The suggestion that it affords the owner information as to depth and pressure of water seems to be discounted by the fact that no marine fishes, which might move in greatly different depths, have this apparatus.

Skeleton

In scientific studies of fishes a knowledge of the fish skeleton, as well as the rest of its anatomy, is desirable. The bones of the skull and shoulder girdle differ decidedly among the different families and frequently form the basis for taxonomic arrangement.

OUTLINE OF CLASSIFICATION OF NATIVE FRESH-WATER FISHES AND LAMPREYS

Class CYCLOSTOMI (or *Cyclostomata*) Lampreys

With funnel-shaped buccal cavity; no jaws; no bones; no operculum; no paired fins

Family PETROMYZONIDAE

Class PISCES True Fishes

With bony jaws; with gill cover or operculum; usually with paired fins

Super-order GANOIDEA Ganoid Fishes

Tail heterocercal; notochord present although restricted; cranium partly cartilaginous

Order GLANIOSTOMI

Mouth inferior and tube-like; several rows of large bony plates on sides, sometimes shed in old age; operculum not bony

Family ACIPENSERIDAE Sturgeons

Order SELACHOSTOMI

Snout prolonged into a broad flat paddle; operculum not bony

Family POLYODONTIDAE Paddlefish

Order HOLOSTEI

Scales rhombic; jaws elongate; vertebrae opisthocoelus

Family LEPISOSTEIDAE Gars

Order HALECOMORPHI

Scales cycloid; with a large gular plate between the rami of the lower jaw

Family AMIIDAE Bowfin, River Dogfish

Super-order TELEOSTEI Bony Fishes

Tail homocercal; notochord never complete; cranium completely ossified

Order ISOSPONDYLI

No spines in fins; pelvic fins abdominal; air bladder open to gullet

Family HIODONTIDAE Mooneyes

Family CLUPEIDAE Herrings

Family DOROSOMIDAE Gizzard Shad

Family SALMONIDAE Salmon, Trout

Family COREGONIDAE Whitefish

Family THYMALLIDAE Graylings

Family OSMERIDAE Smelts

Order APODES

Body elongate, cylindrical; no pelvic fins; no true fin spines; scales, when present, minute and deeply embedded

Family ANGUILLIDAE True Eels

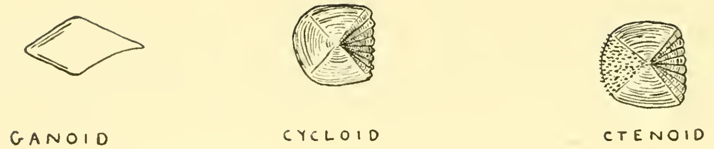
(Several marine families)

Order HETEROGNATHI

Fins soft; with four anterior vertebrae partly fused and with Weberian ossicles; pelvic fins abdominal; brain case not extending between orbits

Family CHARACINIDAE Characins

(Several tropical genera and species)



TYPES OF SCALE — FREE MARGINS TO THE LEFT

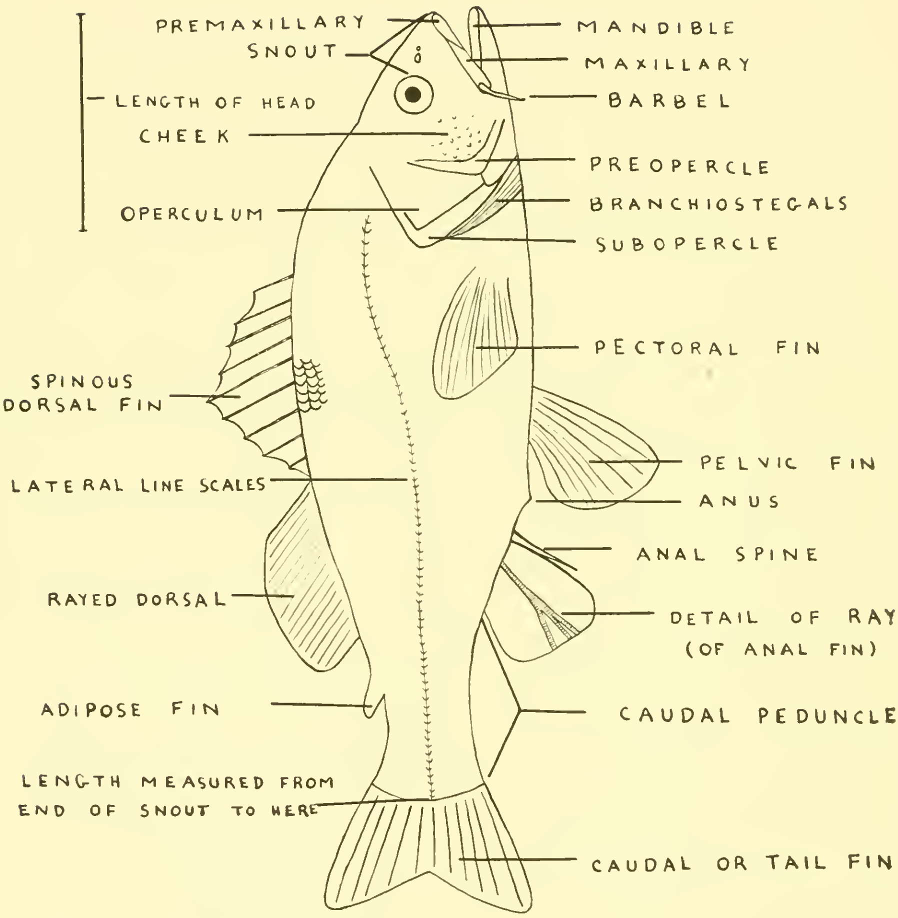


DIAGRAM OF A FISH

Order EVENTOGNATHI

As *Heterognathi*, but with brain case produced between orbits

Family CATOSTOMIDAE Suckers

Family CYPRINIDAE Minnows

Family MEDIDAE Desert Minnows

Order NEMATOGNATHI

Scaleless; the first four vertebrae coossified with the Weberian apparatus

Family AMEIURIDAE Catfishes

Order HAPLOMI

Soft-rayed fishes, with no mesocoracoid; pelvic fins abdominal; maxillary forming side of upper jaw

Family ESOCIDAE Pikes

Family UMBRIDAE Mud-minnows

Family NOVUMBRIDAE Western Mud-minnow

Order CYPRINODONTES

As in *Haplomi*, but with the side of upper jaw formed by the premaxillary

Family CYPRINODONTIDAE Killifishes

Family EMPETRICHTHYIDAE Death Valley Minnow

Family POECILIIDAE Top-minnows

Family AMBLYOPSIDAE Cave Blindfishes

Order SYNENTOGNATHI

Pelvic fins abdominal; dorsal and anal fins without spines; dorsal fin much posterior; air bladder ductless; lateral line forming a ridge along side of belly

Family BELONIDAE Needlefishes

(Many marine genera and species)

Order ANACANTHINI

Pelvic fins jugular; dorsal fin extending almost the length of the back; tail isocercal; scales small or absent

Family GADIDAE Codfishes

(Many marine genera and species)

Order SALMOPERCAE

Dorsal fin with two spines; adipose fin present; head naked; air bladder with rudimentary duct

Family PERCOPSIDAE Trout-perch

Order XENARCHI

With a spiny dorsal fin; anus jugular; scales ctenoid

Family APHREDODERIDAE Pirate-perch

Order HETEROSOMATA

Cranium twisted anteriorly; both eyes on the same side of the

head; body deep and much compressed
Family ACHIRIDAE Soles
(Many marine genera and species)

Order THORACOSTEI
Sides more or less covered with bony plates; pelvic fins subabdominal
Family GASTEROSTEIDAE Sticklebacks

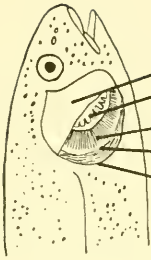
Order PERCOMORPHI
With spiny fins; premaxillary forming whole border of side of upper jaw; no Weberian apparatus; air bladder typically without duct; lower pharyngeals usually separated
Family ATHERINIDAE Silversides
(Several tropical or marine genera and species)
Family PERCIDAE Perches
Family ETHEOSTOMIDAE Darters
Family CENTRARCHIDAE Black Basses and Sunfishes
Family ELASSOMIDAE Pigmy Sunfishes
Family MORONIDAE White Basses
Family SCIAENIDAE Drums or Croakers
(Several tropical or marine genera and species)

Order CATAPHRACTI
A bony process (suborbital stay) extending from below eye across cheek (usually concealed by skin); pelvic fins thoracic or lacking
Family COTTIDAE Sculpins
(Many marine genera and species)

Order HOLCONOTI
Resembling *Percomorphi,* but viviparous and with lower pharyngeals united
Family EMBIOTOCIDAE Surf-fishes
(Several marine genera and species)

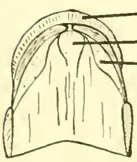
Order CHROMIDES
Resembling *Percomorphi,* but with the lower pharyngeals united and with a single nostril opening on each side
Family CICHLIDAE Cichlids
(Many tropical genera and species)

Order GOBOIDEA
Pelvic fins thoracic, close together or joined; usually no air bladder; no pyloric caeca; superficially like *Etheostomidae,* but without lateral line and with gill membranes joined to isthmus
Family ELEOTRIDAE Sleepers
Family GOBIIDAE Gobies
(Many marine species in tropical waters)

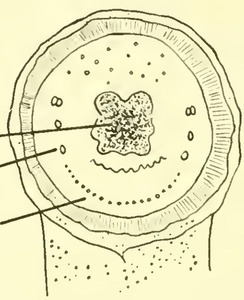


THE PHARYNGEAL TEETH

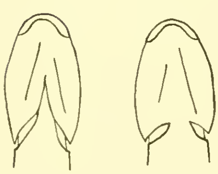
LOWER PHARYNGEAL BONE
(ENLARGED)



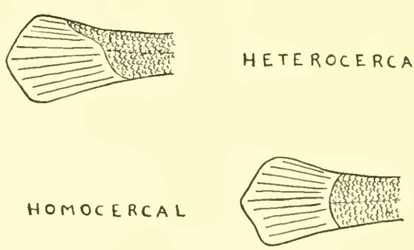
FISH - ROOF OF MOUTH



LAMPREY — BUCCAL DISC



GILL MEMBRANES



TYPES OF TAIL

KEY TO THE COMMON SPECIES OF FISHES AND LAMPREYS

1. Body snake-like, long and cylindrical; scales never evident 2.
   Body not snake-like; scaled or scaleless 11.

2. Gills covered by the operculum; bony jaws present; ascending streams from the Atlantic; Family *Anguillidae*
   - *Anguilla rostrata* (LeSueur) American Eel
   - *Anguilla bostoniensis* (LeSueur)
   - (*Anguilla chrysypa* Raf.)

   With several external gill openings; no operculum; mouth round, without bony jaws; often parasitic on fishes; marine or fresh water; Family *Petromyzonidae* Lampreys 3.

3. Teeth evenly distributed in radiating series around the mouth opening 4.
   Teeth placed in groups around the mouth opening 6.

4. Dorsal fin in two separate portions; Atlantic states, ascending streams from the sea
   - *Petromyzon marinus* Linn. Sea Lamprey

   Dorsal fin continuous, although often deeply notched in the middle; central states (For revision of Genus *Ichthyomyzon* see Hubbs and Trautman, 1937, Univ. of Mich. Museum of Zoology Misc. Pub. No. 35) 5.

5. Sucker around the mouth wider than the body, when expanded; parasitic on fishes; Great Lakes and the Mississippi Valley
   - *Ichthyomyzon concolor* (Kirtland) Silver Lamprey
   - *Ichthyomyzon unicuspis* Hubbs
   - (and related species)

   Sucker around the mouth narrower than the body, when expanded; not parasitic; Great Lakes region and the Mississippi Valley
   - *Reighardina unicolor* (De Kay) Lake Lamprey
   - *Ichthyomyzon fossor* R. & C.
   - (and related species)

6. With a row of small teeth below the mouth opening, connecting the large lateral teeth (all within the ring of marginal teeth); dorsal fins separate 7.
   No row of small teeth connecting the lateral teeth below; dorsal fins separate or connected 9.

7. With three large bicuspid teeth on each side of the mouth opening; northeastern and north-central states
   - *Lethenteron appendix* (De Kay) Eastern Brook Lamprey
   - *Entosphenus lamottenii* (LeSueur)
   - (*Lampetra wilderi* Gage)

   With four large teeth on each side of the mouth, the first and last bicuspid, the middle two tricuspid; ascending streams from the Pacific 8.

8. With 57 to 67 muscle segments from the gills to the anus; color greenish; California
   - *Entosphenus ciliatus* (Ayres) Green Lamprey

   With 68 to 74 muscle segments from the gills to the anus; color brownish; West Coast
   - *Entosphenus tridentatus* (Gairdner) Western Lamprey

9. Area directly before the mouth (within the marginal ring of teeth) toothless, with two small teeth on each side of this area; with 50 to 62 muscle segments from the gills to the anus; Ohio and Potomac Valleys

Okkelbergia lamotteni (LeSueur) Ohio Lamprey

Lampetra aepyptera (Abbott)

Area directly before the mouth toothed; with 57 to 70 muscle segments from the gills to the anus; western North America 10.

10. Dorsal fins well separated; parasitic

Lampetra ayresii (Günther) Western Brook Lamprey

Lampetra fluviatilis (Linn.)

Bases of dorsal fins connected; not parasitic

Lampetra planeri Bloch Western Brook Lamprey

11. Tail heterocercal (backbone ending above the center of the root of the tail fin or extending into the upper portion of the tail); large fishes 12.

Tail homocercal (backbone ending at the center of the root of the tail fin) 24.

12. No scales or with rows of large bony plates 13.

With regular scales 20.

13. No plates or shields; with two very tiny barbels beneath the paddle-like snout; Mississippi River; Family *Polyodontidae*

Polyodon spathula (Walbaum) Paddlefish, Spoonbill

With a series of large bony plates, except in old fishes; with four distinct barbels on the lower side of the upper jaw before the mouth; Family *Acipenseridae* Sturgeons 14.

14. No spiracular opening; caudal peduncle almost cylindrical, without plates 15.

With a small spiracular opening before and above each opercular opening; caudal peduncle flattened, covered with bony plates 16.

15. Belly with subrhombic plates; with 28 or 29 rays in the dorsal fin; Mississippi drainage

Scaphirhynchus platorynchus (Raf.) Shovel-nosed Sturgeon

Belly without plates; with 35 to 43 rays in the dorsal fin; Mississippi and Missouri rivers; rare

Parascaphirhynchus albus F. & R. White Sturgeon

16. Dorsal fin with more than forty rays 17.

Dorsal fin with less than forty rays 18.

17. With about forty plates along each side of the body; Pacific slope

Acipenser transmontanus Richardson Pacific White Sturgeon

With about thirty plates along each side of the body; ascending streams from the Atlantic

Acipenser brevirostris LeSueur Short-nosed Sturgeon

18. With very many tiny plates between the dorsal plates and the row of enlarged lateral plates; Mississippi Valley; Great Lakes

Acipenser fulvescens Raf. Lake Sturgeon

(*Acipenser rubicundus* LeSueur)

With five to ten rows of small plates so situated 19.

19. Color grayish; ascending streams from the Atlantic
Acipenser oxyrhynchus Mitchill Common Sturgeon
Color greenish, with a stripe lengthwise along each side and along the mid-ventral line; ascending streams from the Pacific
Acipenser acutirostris Ayres Green Sturgeon
(*Acipenser medirostris* Ayres)

20. Scales rounded; eastern and central states; Family *Amiidae*
Amia calva Linn. River Dogfish, Bowfin
Scales rhombic; mouth in the form of a narrow beak full of sharp teeth; Family *Lepisosteidae* Gar Pikes 21.

21. With two rows of large teeth on each side of upper jaw in adults; tail fin with many small dark spots; south-central states
Atractosteus spatula (Lacépède) Alligator Gar
(*Atractosteus tristoechus* (B. & S.))
Adults with one row of large teeth on each side of upper jaw; tail fin with several large dark spots (about the size of the eye) 22.

22. Least width of beak less than one-fifteenth of its length; caudal peduncle longer than depth of body; eastern and central U. S.
Lepisosteus osseus (Linn.) Long-nosed Gar
Least width of beak more than one-tenth of its length, in the adult; caudal peduncle as long as depth of body; Mississippi Valley 23.

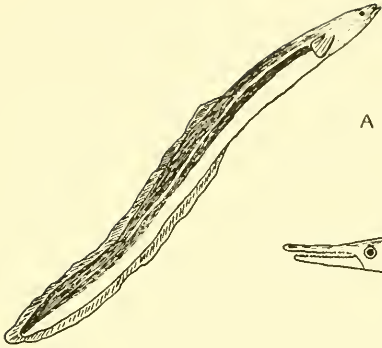
23. Top of head spotted; usually less than fifty-nine scales in the lateral line
Cylindrosteus agassizii Duméril Spotted Gar
Lepisosteus productus Cope
No spots on top of head; usually more than fifty-nine scales in lateral line
Cylindrosteus platostomus (Raf.) Short-nosed Gar
Lepisosteus platostomus Raf.

24. With both eyes on one side of the head; body much flattened sideways, with one side dark colored and one side light colored; ascending streams from the Atlantic and Gulf coasts; Family *Achiridae*
Achirus fasciatus Lacépède Sole
Not so 25.

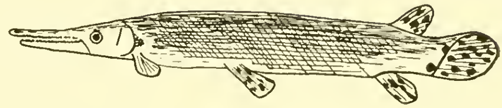
25. With a median chin barbel; dorsal fin extending almost the length of the back and divided into a short anterior and a long posterior section; pelvic fins inserted before the pectorals; northeastern and north-central states; Family *Gadidae*
Lota maculosa (LeSueur) Burbot, Ling, Fresh-water Cod
Lota lota maculosa (LeSueur)
Not so 26.

26. With an apparently scaleless skin and with four to eight long barbels around the mouth; Family *Ameiuridae* Catfishes 27.
Not so 46.

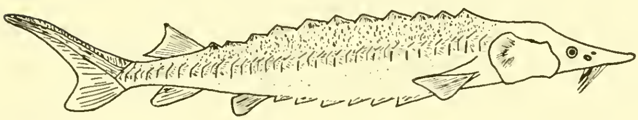
27. Posterior margin of adipose fin (a small flap of skin without any supporting rays, between the dorsal fin and the tail) joined to back 28.
Posterior margin of adipose fin free 35.



ANGUILLA ROSTRATA



CYLINDROSTEUS PLATOSTOMUS



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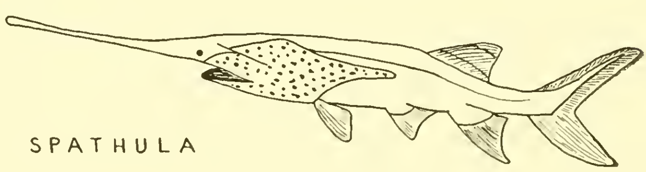
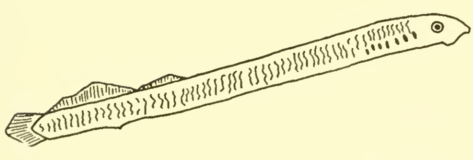
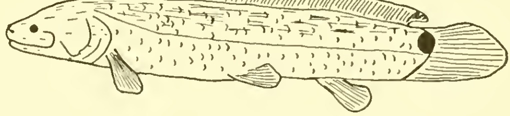


POLYODON SPATHULA



LETHENTERON APPENDIX



AMIA CALVA

28. Band of premaxillary teeth with a narrow backwards extension on each side; adipose fin separated from the tail fin by a distinct notch; spine in the pectoral fin almost smooth behind; about nine inches long; Great Lakes to Texas

Noturus flavus Raf. Stone Cat

Band of premaxillary teeth sharply truncated on each side; not with the combination of other characters as above; not over five inches, except *R. insignis* The Mad Toms 29.

29. Pectoral spine smooth behind or with a few weak serrations near base 30.

Pectoral spine serrate, the serrations being about one-third or more the diameter of the spine 32.

30. Jaws equal; eastern and central U. S.

Schilbeodes gyrinus (Mitchill) Tadpole Cat

Schilbeodes mollis (Hermann)

Lower jaw definitely shorter than the upper 31.

31. Head wide; color dark, sprinkled with black spots; fins with pale edges; Mississippi Valley

Rabida nocturna (J. & G.) Freckled Stonecat

Schilbeodes nocturnus (J. & G.)

Head longer than wide; color yellowish; Gulf States

Rabida leptacantha (Jordan) Yellow Madtom

Schilbeodes leptacanthus (Jordan)

32. Pectoral spine strongly serrate behind, the serrations being almost as long as the diameter of the spine; with a distinctly mottled color pattern 33.

Pectoral spine less strongly serrate behind, the serrations being shorter than one-half the diameter of the spine; color more even 34.

33. Distance from end of snout to the base of the dorsal fin less than one and one-half times the distance from the notch between the adipose and the tail fin and the end of the tail fin; with a dark blotch extending to the edge of the adipose fin; Mississippi Valley and streams flowing into Lake Michigan

Rabida miura (Jordan) Brindled Stonecat

Schilbeodes miurus (Jordan)

Distance from end of snout to the base of the dorsal fin more than one and one-half times the distance from the notch between the adipose and the tail fin to the end of the tail fin; with a dark blotch on the base of the adipose fin; southeastern and south-central states, north to Indiana

Rabida eleuthera (Jordan) Furious Mad Tom

Schilbeodes eleutherus (Jordan)

(Includes *R. furiosa* (J. & M.))

34. With a dark blotch around the front of the dorsal fin; jaws nearly equal; Wisconsin to Kansas

Rabida exilis (Nelson) Slender Stonecat

Schilbeodes insignis (Richardson)

Anterior part of back uniformly colored; upper jaw projecting; N. Y. to S. C.; common east of the Alleghenies

Rabida insignis (Richardson) Mad Tom
Schilbeodes marginatus (Baird)

35. Rays of anal fin less than sixteen; lower jaw longer than upper; band of premaxillary teeth with a narrow backwards extension on each side; Mississippi Valley and Gulf States
Opladelus olivaris (Raf.) Mudcat, Yellow Cat
Pilodictis olivaris (Raf.)
(*Leptops olivaris* (Raf.))
Rays of anal fin sixteen or more; jaws equal or with the upper longer than the lower; band of premaxillary teeth without narrow backwards extensions 36.

36. Tail well forked; color bluish or silvery; bony bridge from head to dorsal fin complete (except in *H. lacustris* and *H. catus,* which have a small gap) 37.
Tail fin rounded or only slightly forked; color brownish or yellowish; with a gap in the bony bridge between the head and the dorsal fin (may be felt through the skin) 41.

37. Anal fin long, usually with 30 to 35 rays; eye low, below the middle of the side of the head; Mississippi Valley and Gulf States
Ictalurus furcatus (C. & V.) Blue Cat, Fork-tail Cat
Anal fin shorter, usually with less rays; eye above the middle of the side of the head 38.

38. Anal fin with nineteen or twenty rays, with its base much shorter than the head; N. Y. to Texas, in coastal streams
Haustor catus (Linn.) White Cat
Ictalurus catus (Linn.)
Anal fin with twenty-three to thirty rays, with its base about as long as the head 39.

39. Area between the eyes concave, with a groove running back to the dorsal fin; Mississippi Valley
Ictalurus anguilla E. &K. Eel Cat
Area between the eyes flattened or slightly convex 40.

40. Bony bridge from head to dorsal fin complete; length of head about one and one-half times the width; body with irregular dark spots; tail fin deeply forked, with the upper lobe smaller and more pointed than the lower; Great Lakes to the Gulf
Ictalurus punctatus (Raf.) Channel Cat
Ictalurus lacustris punctatus (Raf.)
Usually with a gap in the bony bridge from head to dorsal fin; head wider; body spotted or plain colored; tail fin less deeply and more regularly forked; Great Lakes area
Haustor lacustris (Walbaum) Lake Cat
Ictalurus lacustris lacustris (Walbaum)

41. Eyes rudimentary, covered by skin; cave streams of eastern Pennsylvania
Gronias nigrilabris Cope Blind Cat
Eyes normal 42.

42. Body slender; length over five times depth; upper jaw strongly projecting; southeastern U. S.
Ameiurus platycephalus (Girard) Brown Catfish
Depth more than one-fifth of length; jaws various 43.

43. Anal rays 23 to 27; chin barbels whitish; Great Lakes and southwards
Ameiurus natalis (LeSueur) Yellow Bullhead
Anal rays 17 to 25; chin barbels gray to black 44.

44. Pectoral spines short, slightly over one-third length of head, almost smooth; anal fin with light rays contrasting with dark membranes; jaws almost equal; New England to Neb. and southwards
Ameiurus melas (Raf.) Black Cat
Pectoral spines longer, almost one-half length of head, serrate in *A. nebulosus;* fins more uniformly colored; upper jaw projecting in *A. nebulosus* 45.

45. Color usually mottled or blotched; upper jaw longer than lower; Maine to N. D. and southwards
Ameiurus nebulosus (LeSueur) Common Bullhead, Horned Pout
Color usually plain dark above; jaws almost equal; southeastern U. S.
Ameiurus erebennus Jordan Black Cat

46. With an adipose fin (a small flap of skin without any supporting rays, between the dorsal fin and the tail) 47.
No adipose fin 74.

47. With three branchiostegals (rays in each gill membrane ventral to the operculum); no pseudobranchiae (small gills on the under side of the operculum); southern Texas; Family *Characinidae* (mostly tropical species)
Astyanax mexicanus (Filippi) Characin
With four or more branchiostegals; with pseudobranchiae 48.

48. Pectoral fins extending well back beyond the insertion of the pelvic fins; with two spines in the anterior end of the dorsal fin; Family *Percopsidae* Trout-perch 49.
Pectoral fins not extending back beyond the insertion of the pelvics; no spines in the dorsal fin Trout, Salmon, Whitefish and Graylings 50.

49. Dorsal spines weak; lateral line complete; northeastern and north-central states
Percopsis omiscomaycus (Walbaum) Trout-perch, Sand-roller
(*Percopsis guttatus* Agassiz)
With two strong dorsal spines; lateral line more or less incomplete; Pacific Slope
Columbia transmontana E. & E. Western Trout-perch

50. Lower jaw articulating under or before the eyes; with less than one hundred scales in the lateral line 51.
Lower jaw articulating behind the eyes; scales very small, more than one hundred in the lateral line; Family *Salmonidae* Trout and Salmon 62.

51. With nineteen to twenty-two rays in the dorsal fin; upper Missouri valley; Family *Thymallidae* Graylings
Thymallus montanus Milner Grayling

With fifteen or less rays in the dorsal fin 52.

52. With eight to ten branchiostegals; seldom over twelve inches long; ascending streams from the Atlantic and Pacific; Family *Osmeridae* Smelts 53.

With ten or more branchiostegals; often larger; lake species; Family *Coregonidae* Whitefish and Lake Herrings 55.

53. With twenty-one rays in the anal fin; northern Pacific slope
Thaleichthys pacificus (Richardson) Candlefish

With fourteen to sixteen rays in the anal fin 54.

54. Pectoral fins reaching about to the insertion of the pelvic fins; ascending streams from the Pacific
Spirinchus thaleichthys (Ayres) Pacific Smelt

Pectoral fins much shorter; ascending streams from the Atlantic, often landlocked
Osmerus mordax (Mitchill) American Smelt, Icefish

55. Upper jaw extending scarcely, if any, beyond the lower jaw; Great Lakes and surrounding territory Lake Herrings (Several species, only the most common of which are given here. For details of this group, see Koelz, 1931, Papers Mich. Acad. Sci., Arts and Letters, 13 (1930)) 56.

Lower jaw conspicuously overhung by the upper which has the premaxillaries turned downwards 59.

56. Lower jaw projecting noticeably beyond the upper; tip of lower jaw usually with a symphyseal knob
Leucichthys hoyi (Gill) Cisco, Bloater

Jaws almost equal 57.

57. Usually with less than forty gill rakers on the gill arch; lower jaw pale
Leucichthys zenithicus (J. & E.) Short-jawed Chub

Usually with more than forty gill rakers on the gill arch; lower jaw pigmented, at least toward the tip 58.

58. Body deepest anteriorly
Leucichthys nigripinnis (Gill) Blackfin

Body deepest through the middle
Leucichthys artedi (LeSueur) Common Lake Herring

59. With 17 to 20 gill rakers on the lower section of the first gill arch (below the bend); body much compressed; Great Lakes
Coregonus clupeaformis (Mitchill) Whitefish

With 12 to 16 gill rakers on the lower section of the first gill arch; body not so much compressed 60.

60. Base of adipose fin as long as the base of the anal fin; Columbia River valley
Irillion oregonius (J. & S.) Chisel-mouth Jack

Base of adipose fin shorter (Several species, of which the two most widely distributed are given) 61.

61. Upper jaw not reaching to below the front of the eye; New England to the Great Lakes

Prosopium quadrilaterale (Richardson) Frostfish, Pilot
Prosopium cylindraceum quadrilaterale (Richardson)

Upper jaw reaching below the front of the eye; western states
Prosopium williamsoni (Girard) Rocky Mountain Whitefish

62. Anal fin with thirteen to seventeen rays; ascending streams from the Pacific; breeding males usually with red coloring 63.
Anal fin with less than thirteen rays 67.

63. Scale count over 170; tail with oval dark spots in adults
Oncorhynchus gorbuscha (Walbaum) Humpback Salmon
Scale count less than 160; tail with or without spots 64.

64. With 30 to 40 gill rakers on the first gill arch; color blue above, unspotted
Oncorhynchus nerka (Walbaum) Sockeye, Blueback
With 20 to 25 gill rakers on the first gill arch 65.

65. Head depressed, snout produced, with eye about midway in head; with or without fine dots, but no definite dark spots
Oncorhynchus keta (Walbaum) Dog Salmon
Head conical; eye anterior in head; back often spotted 66.

66. Usually with 15 to 17 rays in the anal fin; back and tail well spotted
Oncorhynchus tschawytscha (Walbaum) Chinook, King Salmon
Usually with 13 or 14 rays in the anal fin; back often spotted, tail usually less so
Oncorhynchus kisutch (Walbaum) Silver Salmon, Coho

67. Sides with some red or orange spots (red lost in preserved specimens); pectoral and pelvic fins with white outer rays or borders (Only the most common species are given here) 68.
Spots yellowish or dark; with or without red blotches or a red band along each side; no white outer borders to pectorals and pelvics (Only widely distributed species are included) 71.

68. Scale count about 120; with inconspicuous white borders to the pectoral and pelvic fins; usually with some of the spots cross or star-shaped; an introduced European species
Salmo trutta Linn. Brown Trout
Salmo trutta fario Linn.
(*Trutta eriox* (Linn.))
Scale count usually over 200; with conspicuous white borders to the pectoral and pelvic fins; dark spots usually not cross or star-shaped; native species Charrs 69.

69. Back pale-spotted above; western species
Salvelinus malma spectabilis (Girard) Dolly Varden Trout
Back not pale-spotted above; eastern species 70.

70. Back marbled with dark coloring in adults; maxillary extending well beyond the eye; eastern states, and introduced into some western states
Salvelinus fontinalis (Mitchill) Brook Trout
Back not marbled with dark; maxillary extending scarcely beyond the eye; N. H. and Vermont
Salvelinus aureolus Bean Golden Trout, American Saibling

71. Back dark, with numerous small yellowish spots; northern states
Cristivomer namaycush (Walbaum) Lake Trout, Togue
Spots darker than body color 72.

72. Scale count about 120; males with red blotches; breeding males with the lower jaw strongly hooked upwards; north Atlantic, entering rivers south to Cape Cod
Salmo salar Linn. Atlantic Salmon
(Landlocked subspecies "*sebago*")
Scale count more than 130; western species, also introduced into the eastern states 73.

73. With a red streak on each side of the lower jaw along the inner sides of the mandibles; males sometimes with red coloring on the sides; tail spotted
Salmo clarkii (Richardson) Cutthroat Trout
(*Trutta clarkii* (Richardson))
No red streaks so situated; usually with a reddish band along each side; tail not spotted in young (Formerly considered to be two species, the silvery, sea-going "Steelhead" and the heavily spotted, fresh-water "Rainbow")
Salmo gairdnerii (Richardson) Rainbow Trout or Steelhead
(Includes *Salmo shasta* (Jordan) or *Salmo irideus* Gibbons)

74. Anus jugular 75.
Anus in the normal position before the anal fin 81.

75. Pelvic fins thoracic; eyes normal; about seven to eight inches long; N. Y. to Texas; Family *Aphredoderidae*
Aphredoderus sayanus (Gilliams) Pirate-perch
Pelvic fins absent or else very small and abdominal; eyes very small or absent; less than six inches long; Family *Amblyopsidae* Cave Fishes 76.

76. With small eyes; body colored; no pelvic fins 77.
Eyes concealed; body colorless; with or without pelvic fins 79.

77. Sides brown, unstriped; underground streams of Kentucky
Forbesella agassizii (Putnam) Kentucky Cavefish
With three dark stripes on each side 78.

78. With ridges of sensory papillae on the sides of the body; in Illinois caves
Forbesella papillifera (Forbes) Illinois Cavefish
No sensory papillae on sides of body; in swamps of southern states
Chologaster cornutus Agassiz Rice-ditch Fish

79. With small pelvic fins; caves of Kentucky and Indiana
Amblyopsis spelaeus De Kay Mammoth Cave Blindfish
No pelvic fins 80.

80. Pectoral fins not reaching back to the anal fin; cave streams from Indiana to Alabama
Typhlichthys subterraneus Girard Small Blindfish
Pectoral fins reaching back to the insertion of the anal fin; caves of Missouri and Arkansas
Troglichthys rosae (Eigenmann) Missouri Cavefish

81. No spines in the dorsal fin; pelvic fins absent or abdominal (first ray or spine nearer to the first soft ray of the anal fin than to the union of or line between the lower corners of the gill membranes) 82.

Dorsal fin with or preceded by one or more spines, which sometimes appear as a soft-spined finlet preceding the dorsal fin or as an anterior dorsal fin; pelvic fins jugular, thoracic, abdominal or absent 272.

82. Lateral line running along each side of the belly; mouth in the form of a narrow beak full of sharp teeth, resembling a gar's; Atlantic and Gulf coasts, ascending streams; Family *Belonidae* (many marine species)

Strongylura marina (Walbaum) Garfish, Billfish

Lateral line, if present, running along each side of the body; mouth not so 83.

83. Head with scales (sometimes minute, best seen by scraping the head gently towards the front); either with the jaws flattened and shaped somewhat like a duck's beak, or else small fishes, with the tail scarcely or not emarginate 84.

Head without scales; jaws not as above in most species; tail usually distinctly emarginate or forked (except in one introduced species, *Tinca tinca* Linn.) 114.

84. Jaws shaped like a duck's beak; lateral line present, although sometimes faint; tail forked; Family *Esocidae* Pikes 85.

Jaws not so; no lateral line or with merely a few scattered pores (a dark lateral stripe may or may not be present); tail scarcely or not emarginate; seldom over six inches long 89.

85. No scales on lower half of cheek; branchiostegals (rays in each gill membrane below the operculum) seventeen to nineteen; (sides dark barred or spotted in subspecies *ohiensis*, plain colored in subspecies *immaculatus* or Great Northern Pike); Ohio Valley, Wisconsin and Minnesota; Chautauqua Lake, N. Y.

Esox masquinongy Mitchill Muskallunge, Great Pike

Cheeks wholly scaled; with eleven to sixteen branchiostegals 86.

86. No scales on the lower half of the operculum; with rows of light spots along the sides; northern states (An unspotted variety called the "Silver Pike" is found in Minnesota)

Esox estor LeSueur Common Pike, Pickerel

Esox lucius Linn.

Operculum all scaled; sides with dark markings 87.

87. With fourteen rays in the dorsal fin, thirteen in the anal; scale count over 115; with a network of dark lines on the sides; Atlantic and Gulf states

Esox niger LeSueur Chain Pickerel, Common Eastern Pickerel (*Lucius reticulatus* (LeSueur))

Dorsal and anal fins each with eleven or twelve rays; scale count less than 115 88.

88. Usually with irregular dark markings; tributaries of the eastern Great Lakes and the Mississippi Valley

Esox vermiculatus LeSueur Grass Pickerel, Little Pickerel

Usually with about twenty dark bars on each side; east of the Alleghenies (Possibly a variation of *E. vermiculatus*)
Esox americanus Gmelin Barred Pickerel

89. Upper lip protractile, separated from the forehead by a distinct groove
Top-minnows and Killifishes 90.
Not so Mud-minnows 112.

90. Pelvic fins usually absent; desert species of the southwest 91.
Pelvic fins usually present 93.

91. Sides of female with obscure dark bars; males blue; depth of body almost one-half the length; jaw teeth with three points
Cyprinodon nevadensis Eigenmann (of Family *Cyprinodontidae*)
Sides blotched or mottled; body less deep; jaw teeth conical or with two points 92.

92. Sides dark mottled; jaw teeth conical; Family *Empetrichthyidae*
Empetrichthys merriami Gilbert Death Valley Minnow
Sides with dark blotches arranged in lengthwise rows; jaw teeth with two points
Cyprinodon baileyi Gilbert (of Family *Cyprinodontidae*)
Crenichthys baileyi (Gilbert)

93. Anal fin of male long and sword-shaped; body of female enlarged through the region of the abdomen; viviparous species; Family *Poeciliidae* 94.
Anal fin normal; abdomen more compressed; not viviparous; Family *Cyprinodontidae* 97.

94. Dorsal fin with about fifteen or sixteen rays; anal fin of female with about eight rays; southern states to Texas
Mollienesia latipinna LeSueur Mudfish, Mollie
Dorsal fin with about seven to nine rays; anal fin of female with about six to ten rays 95.

95. Dorsal fin starting above or before the beginning of the anal fin; Colorado River basin
Poeciliopsis occidentalis (B. & G.)
Dorsal fin more posterior than the anal fin 96.

96. Lower jaw weak; teeth movable; southern states
Heterandria formosa Agassiz Top-minnow
Lower jaw projecting; teeth slightly movable; southern Atlantic and Gulf coasts and lower Mississippi Valley
Gambusia patruelis (B. & G.) Viviparous Top-minnow
Gambusia affinis (B. & G.)

97. Dorsal fin more posterior than the anal fin, with eleven or less rays 98.
Dorsal fin usually starting above or before the beginning of the anal fin, with nine or more rays 102.

98. Dorsal fin with nine or ten rays; sides plain colored or each with a dark lengthwise band 99.
Dorsal fin with seven or eight rays; sides barred or striped or with lengthwise rows of dark spots 100.

99. With a dark band lengthwise along each side; central states
Zygonectes notatus (Raf.) Striped Top-minnow
Fundulus notatus (Raf.)
Plain greenish colored; S. D. to Colorado
Zygonectes sciadicus (Cope) Western Top-minnow
(*Fundulus sciadicus* Cope)

100. Fins red; with about fifteen faint cross bars; N. Y. to Florida
Zygonectes cingulatus (C. & V.) Banded Top-minnow
(*Fundulus cingulatus* C. & V.)
Fins not red; with nine to twelve cross bars or with lengthwise stripes or rows of spots 101.

101. Scales dark-edged, with these spots arranged in lengthwise rows; Gulf states
Zygonectes guttatus Agassiz Spotted Top-minnow
(*Fundulus guttatus* (Agassiz))
Male with rows of dark spots and with dark bars; female with dark stripes; central states
Zygonectes dispar Agassiz Starhead Top-minnow
Fundulus dispar Agassiz

102. Depth of body almost one-half the length, with the anterior area elevated; females dark barred; males blue above, yellow to red below 103.
Body more slender 104.

103. In the Atlantic and Gulf states
Cyprinodon variegatus Lacépède Sheephead Minnow, Pursy Minnow
Desert species of the southwest
Cyprinodon macularius B. & G. Desert Minnow

104. Scale count usually over forty or length about five times depth or both 105.
Scale count usually less than forty; body less slender 108.

105. Body orange spotted 106.
Sides with dark bars 107.

106. Scales with orange spots forming rows; south-central states and Ozark region
Xenisma catenatum (Storer) Studfish
Body irregularly orange spotted; Alabama river system
Xenisma stellifer Jordan Alabama Studfish

107. Body slender, being almost five times as long as deep; scale count 35 to 55; eastern and north-central U. S. (Subspecies *menona* is the western subspecies distinguished by having diffuse bars forming a lengthwise stripe toward the tail)
Zygonectes diaphanus (LeSueur) Menona Top-minnow
Fundulus diaphanus (LeSueur)
Body less slender; scale count about 60; S. D. to New Mexico
Plancterus zebra (Girard) Zebra Top-minnow
(*Fundulus zebrinus* J. & G.)

108. With one row of teeth in each jaw; usually with nine to twelve rays in the dorsal fin; scale count 25 to 32 109.

Teeth in two or more rows; usually with eleven to thirteen rays in the dorsal fin; scale count 34 to 39 110.

109. Depth of body about one-fourth of length; with a dark stripe along each side ending in a spot at the base of the tail fin; Florida everglades

Chriopeops goodei (Jordan) Florida Killifish

(*Lucania goodei* Jordan)

Depth of body about one-third of length; sides and back greenish; with a dark spot at the base of the dorsal fin; Atlantic and Gulf coasts

Lucania parva (B. & G.) Rainwater Fish, Little Killifish

110. Fins plain colored; dorsal fin usually with thirteen rays; sides of male dark barred; southern West Coast

Fundulus parvipinnis Girard Western Killifish

Fins with light or dark spots; dorsal fin usually with eleven or twelve rays; Atlantic and Gulf coasts 111.

111. Snout short, about equal in length (before eye) to the diameter of the eye; fins usually pale spotted; females mostly plain colored; males with silvery bars on sides; Atlantic and Gulf coasts

Fundulus heteroclitus (Linn.) Common Killifish, Mummichog

Snout longer; fins usually dark blotched; with dark bars (males) or dark stripes; Atlantic coast

Fundulus majalis (Walbaum) Mayfish

112. Scale count about 50 to 60; with 18 to 25 rays in the pectoral fins; sides dark barred, faintly dark striped in the breeding season; northwestern U. S.; Family *Novumbridae*

Novumbra hubbsi Schultz Western Mud-minnow

Scale count about 30 to 40; with about 14 rays in the pectoral fins; sides dark barred or dark striped; eastern and central states; Family *Umbridae* 113.

113. With transverse bars; northeastern and north-central states

Umbra limi (Kirtland) Eastern Barred Mud-minnow

With lengthwise stripes; Atlantic slope

Umbra pygmaea (De Kay) Eastern or Striped Mud-minnow

114. Gill membranes (thin wall of skin closing the gill chamber below) free from the isthmus (fleshy part between the gill openings), so that they appear split far forward and meeting at an acute angle below the chin; jaw teeth may or may not be present 115.

Gill membranes broadly joined to the isthmus; no teeth on the jaws 121.

115. Lateral line present; Family *Hiodontidae* 116.

No lateral line 117.

116. With nine rays in the dorsal fin; Ohio Valley and Great Lakes

Amphiodon alosoides Raf. Goldeyes

With twelve rays in the dorsal fin; Mississippi Valley

Hiodon tergisus LeSueur Mooneye, Silver Bass

117. Last ray of dorsal fin much elongated; eastern and central states; Family *Dorosomidae*

Dorosoma cepedianum (LeSueur) Gizzard Shad
Dorsal fin not so; Family *Clupeidae* Herrings 118.

118. Toothless; upper jaw appearing notched at tip 119.
With weak teeth; upper jaw not notched 120.

119. With one or more small dark spots behind the operculum; ascending streams from the Atlantic; introduced on the Pacific slope
Alosa sapidissima (Wilson) Common Shad
Without such spots; Ohio River, Mississippi Valley
Alosa ohiensis Evermann Ohio Shad

120. With a small black spot behind the operculum; Atlantic states
Pomolobus pseudoharengus (Wilson) Alewife
No such spot; Mississippi Valley and Gulf
Pomolobus chrysochloris Raf. Skipjack, Blue Herring

121. Dorsal fin with more than ten rays (rarely as few as nine) or else with the lips thick, wrinkled, and covered with minute projections; with numerous pharyngeal teeth in a comb-like series; Family *Catostomidae* Suckers 122.
Dorsal fin with not more than ten rays; lips usually thinner; edge of upper jaw formed by the premaxillaries alone; with less than ten teeth on each pharyngeal bar; Family *Cyprinidae* Minnows 157.

122. Dorsal fin long, with twenty-three to forty rays 123.
Dorsal fin shorter, with nine to twenty rays 130.

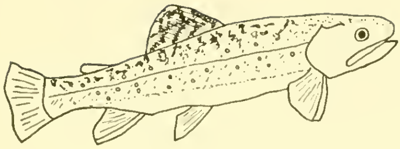
123. Scales small, about fifty-six in the lateral line; eye behind middle of head; Mississippi Valley
Cycleptus elongatus (LeSueur) Blackhorse, Missouri Sucker
Scales larger, not over forty-five in the lateral line; eye before middle of head 124.

124. Longest ray of dorsal fin usually shorter than one-half the base of the dorsal fin; anterior fontanelle (on front of skull) reduced or absent; Mississippi Valley 125.
Longest ray of dorsal fin usually one-half or more as long as the base of the fin; with a well developed anterior fontanelle 127.

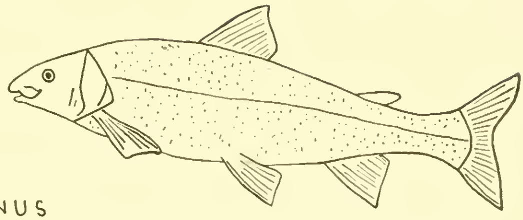
125. Mouth terminal, very oblique, about on a level with the lower margin of the eye; gill rakers on first arch, counted from posterior face, almost 100
Megastomatobus cyprinella (C. & V.) Common Buffalo
Mouth subterminal to inferior, less oblique; upper lip below the level of the lower margin of the eye; gill rakers so situated less than 60 126.

126. Back with a high elevation; depth of body more than one-third the length
Ictiobus bubalus (Raf.) Small-mouth or Razor-back Buffalo
Back only slightly elevated; depth of body about one-third the length (Not clearly distinct from the preceding species)
Ictiobus urus (Agassiz) Mongrel or Black Buffalo
Ictiobus niger (Raf.)

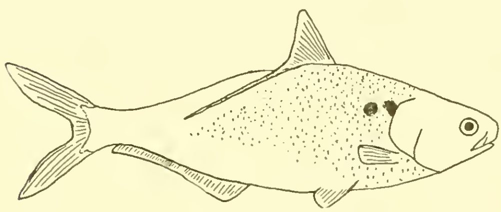
127. Longest ray of dorsal fin almost as long as the base of the fin; about a foot long 128.



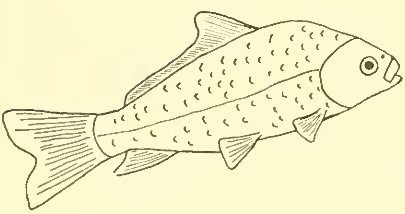
SALVELINUS FONTINALIS



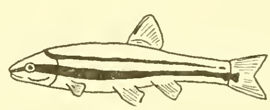
COREGONUS CLUPEAFORMIS



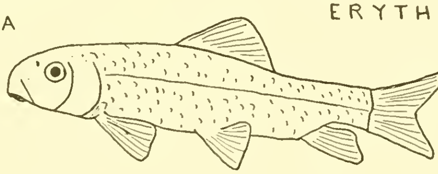
DOROSOMA CEPEDIANUM



MEGASTOMATOBUS CYPRINELLA



CHROSOMUS ERYTHROGASTER



MOXOSTOMA SP.

Longest ray of dorsal fin about half as long as the base of the fin; often larger 129.

128. Mouth mostly before a vertical from the nostrils; Mississippi Valley to the Rio Grande

Carpiodes velifer (Raf.) Quillback
Carpiodes cyprinus (LeSueur)

Mouth farther back, the nostrils being very near the end of the snout; Ohio Valley and westward

Carpiodes difformis Cope Blunt-nosed River Carp
Carpiodes velifer (Raf.)

129. Mouth mostly before a vertical from the nostrils; Nebraska area

Carpiodes thompsoni Agassiz Lake Carp
Carpiodes forbesi Hubbs

Mouth farther back, the nostrils being very near the end of the snout; Ohio Valley to Texas

Carpiodes carpio (Raf.) Common River Carp

130. Scales small, with the scale count more than fifty-five 131.
Scales larger, with the scale count less than fifty-five 148.

131. With a large hump back of the head; Colorado River basin

Xyrauchen texanus (Abbott) Humpback Sucker
(*Xyrauchen cypho* (Lockington))

Not so 132.

132. Upper lip thin; mouth terminal; western states 133.
Upper lip thick; mouth inferior 138.

133. Scale count about 65; Utah and Nevada 134.
Scale count 70 to 80; vicinity of Klamath Lakes, Oregon 136.

134. Lips with numerous tubercles; Utah Lake

Chasmistes fecundus (C. & Y.) Webug Sucker

Lips not tuberculate 135.

135. End of nose high; Utah Lake

Chasmistes liorus Jordan June Sucker

Nose less prominent; Pyramid Lake, Nevada

Chasmistes cujus Cope Couia, Kweewee, Quiwee

136. Snout short and even

Chasmistes brevirostris Cope Yen, Tswam

Spines of premaxillaries projecting to form a knob on top of snout 137.

137. Dark spotted above

Deltistes luxatus (Cope) Lost River Sucker
Chasmistes luxatus Cope

Dusky above

Chasmistes stomias Gilbert Klamath Lake Sucker

138. Head depressed, transversely concave between the eyes; eye well behind middle of head; scales even; scale count 45 to 55; eastern and north-central states

Hypentelium nigricans (LeSueur) Hog Sucker

Head less depressed; position of eye various; scale count often greater; scales smaller and crowded anteriorly 139.

139. Posterior fontanelle (on top of skull) obliterated by the junction of the parietal bones in adult specimens; head $4\frac{1}{2}$ to 5 in length; eye usually behind middle of head; scale count over sixty-five; pelvic fins inserted below the posterior end of the base of the dorsal fin; Rocky Mountain region Mountain Suckers 140.

With a large posterior fontanelle; head 4 to $4\frac{1}{2}$ in length; eye usually about midway in head; other characters various; generally distributed 144.

140. Scale count about 80 141.

Scale count 90 to 100 143.

141. With less than 25 scales before the dorsal fin; brown above; Gila Basin

Notolepidomyzon clarkii (B. & G.) Gila Sucker
(*Pontosteus clarkii* (B. &G.))

With 28 to 50 scales before the dorsal fin 142.

142. Body slender, about five times as long as deep; male with a red stripe along each side; about eight inches long; Colorado Basin

Notolepidomyzon generosus (Girard) Mountain Sucker
(*Pantosteus generosus* (Girard))

Body stouter; male with orange markings; about twelve inches long; Rio Grande Valley

Notolepidomyzon plebius (B. & G.) Rio Grande Sucker
(*Pantosteus plebius* (B. & G.))

143. Tail slender; males with reddish coloring on the sides; tributaries of the Colorado

Pantosteus delphinus (Cope) Bluehead Sucker

Tail peduncle stout; male with an orange stripe along each side; northwestern species

Pantosteus jordani Evermann

144. Scale count more than eighty 145.

Scale count less than eighty 146.

145. Fins very large, the pectorals reaching to below the front end of the base of the dorsal fin, the pelvics reaching almost to the anal fin; upper lip very thick, with five or six rows of small tubercles; lower Colorado Valley

Catostomus latipinnis B. & G. Flannel-mouthed Sucker

Fins much smaller; upper lip thinner, with about three rows of small tubercles; northern states

Catostomus catostomus (Forster) Long-nose or Northern Sucker

146. Scale count 55 to 70; length four to five times depth; Mass. to Colorado

Catostomus commersonii (Lacépède) Common Sucker

Scale count usually over 70; usually more slender, depth being about five in length 147.

147. Upper lip full and overhanging, with six to eight rows of papillae; Columbia River Basin

Catostomus macrocheilus Girard Biglip Sucker

Upper lip thinner, with five or six rows of papillae; California

Catostomus occidentalis Ayres Sacramento Sucker

148. No indication of lateral line 149.
Lateral line present, although sometimes broken 150.

149. Body compressed, about three times as long as deep; with 38 or less evenly arranged scales along the side; west to Texas
Erimyzon sucetta (Lacépède) Chub Sucker, Creek Fish
Body longer, less compressed; with 39 or more irregularly arranged scales along the side; eastern and central states (Considered by some to be a subspecies of the preceding)
Erimyzon oblongus (Mitchill) Chub Sucker, Mullet

150. Lateral line broken; Great Lakes area to Montana
Minytrema melanops (Raf.) Spotted Sucker
Lateral line complete 151.

151. Upper lip not protractile; lower lip in two separate lobes; formerly most of central U. S., possibly extinct
Lagochila lacera J. & B. Rabbit-mouth or Harelip Sucker
Upper lip protractile; lower lip entire or more or less lobed 152.

152. Head transversely concave between the eyes; eye very far back in head; lower lip tuberculate, very thick, with two almost separate lobes; snout much produced downwards; eastern and north-central states
Hypentelium nigricans (LeSueur) Hog Sucker
Head flat above or slightly convex; eye somewhat nearer middle of head 153.

153. Eye somewhat behind middle of head; no posterior fontanelle, the parietal bones being united in this region (on top of skull); restricted region of Virginia and W. Virginia in mountain headwaters
Thoburnia rhothoeca (Thoburn)
Eye about midway in head; with a large posterior fontanelle 154.

154. Mouth large, oblique; with six to ten large cylindrical teeth on the lower part of the pharyngeal bar; Michigan to Georgia and Arkansas
Placopharynx carinatus Cope Big-jaw Sucker
Mouth smaller, horizontal; pharyngeal teeth all small 155.

155. Dorsal rays 12 to 15; under fins often red; getting to be over a foot long in most species; usually found in rivers and ponds (A difficult group. Revised by Hubbs, 1930, Univ. of Michigan Museum of Zool. Misc. Pub. No. 20. A representative species is given here.); eastern and central U. S.
Moxostoma aureolum (LeSueur) Common Redhorse
Dorsal rays 10 to 12; under fins not much reddish; small suckers usually found in mountain streams; south Atlantic states 156.

156. Scales pale spotted in lengthwise rows
Scartomyzon cervinus (Cope) Jumping Mullet, Crawl-a-bottom
Back dusky
Scartomyzon rupiscartes (J. & J.) Jumprocks

157. With a barbel present on the maxillary (minute and usually concealed by the fold near the corner of the mouth) 158.
No trace of maxillary barbel 182.

158. Tail fin slightly emarginate; a moderately large European species introduced into the eastern states
Tinca tinca Linn. Tench
Tail fin distinctly emarginate or forked 159.

159. Upper lobe of tail fin longer than the lower lobe, in adult specimens; about twelve inches long; California
Pogonichthys macrolepidotus (Ayres) Splittail
Lobes of tail fin equal 160.

160 With two barbels on each side of the mouth; two inches long; Arkansas and Kansas
Extrarius tetranemus (Gilbert)
With one barbel on each side of the mouth 161.

161. Premaxillaries not protractile 162.
Premaxillaries protractile 164.

162. Scale count about 50; lips thick; eastern states
Parexoglossum laurae Hubbs Eastern Tonguetied Minnow
Scale count 60 to 70; lips thin 163.

163. Snout projecting considerably beyond the mouth; color dark; widely distributed over northern U. S., south to North Carolina
Rhinichthys cataractae (C. & V.) Long-nosed Dace
Snout projecting very little beyond the mouth; with a dark band along each side; Maine to Minn. and southwards
Rhinichthys atronasus (Mitchill) Black-nosed Dace
Rhinichthys atratulus (Hermann)
(Includes *R. meleagris* Agassiz)

164. Barbel situated before the end of the maxillary 165.
Barbel situated at the end of the maxillary, at the junction of the upper and lower lip 167.

165. Dorsal fin with a distinct black blotch at the base, from the first to the third ray; Maine to N. J. and Wyoming
Semotilus atromaculatus (Mitchill) Horned Dace
No such fin spot 166.

166. Scale count about 45; east of the Alleghenies
Leucosomus corporalis (Mitchill) Fallfish
Scale count 50 to 75; with scattered dark-colored scales forming a spotted pattern above; Lake Erie and southwards
Margariscus margarita (Cope) Pearl Minnow

167. Scales small, 58 to 90 in the lateral line 168.
Scales larger, 35 to 56 in the lateral line 176.

168. Pharyngeal teeth thick, blunt, scarcely hooked, 5-5 in the main row; scale count about 75; with two dark bands along each side; about a foot long; northwestern U. S.
Mylocheilus lateralis A. & P. Columbia River Chub
Mylocheilus caurinus (Richardson)
Pharyngeal teeth slender, hooked, 4-4 in the main row; smaller fishes 169.

169. Barbels well developed; pharyngeal teeth 2-4-4-2; lateral line complete; northern states

Couesius plumbeus (Agassiz) Chub Minnow

Barbels minute; pharyngeal teeth 4-4 or 1-4-4-1; lateral line incomplete in some species 170.

170. Pharyngeal teeth in one row (4-4); scale count over 80; Gila River Basin

Agosia chrysogaster Girard

Pharyngeal teeth in two rows (1-4-4-1); scale count under 80, except in *A. oscula* 171.

171. With ten or eleven rays in the dorsal fin 172.

With eight rays in the dorsal fin 173.

172. Scale count over 60; inner rays of pelvic fins not joined to body; Idaho

Apocope umatilla (G. & E.)

Scale count under 60; inner rays of pelvic fins joined to body; Columbia River Basin

Apocope falcata (E. & E.)

173. Scale count over 80; color greenish, with red patches about the head; Colorado and Gila Rivers

Apocope oscula (Girard)

Scale count under 80 174.

174. Scale count under 70; with one dark band on each side; Columbia River basin and coastwise streams of Wash. and Oregon

Apocope nubila (Girard)

Scale count 70 to 80; Colorado River Basin 175.

175. With two dark bands on each side

Apocope yarrowi (J. & E.)

Dusky above

Apocope couesii Yarrow

176. Head flattened; scale count about 50; headwaters of the Missouri River and surrounding territory

Platygobio gracilis (Richardson) Flat-headed Chub

Head not so much flattened above; scale count various 177.

177. Mouth terminal; eye shorter than upper jaw 178.

Mouth distinctly overhung by snout; eye longer than upper jaw, except in *M. aestivalis* 179.

178. With a round dark spot at the base of the tail fin; northward and eastward from the Ozarks

Nocomis kentuckiensis (Raf.) Hornyhead Chub

Nocomis biguttatus (Kirtland)

Caudal spot irregular and indistinct; eastern and east-central U. S.

Nocomis micropogon (Cope) River Chub

179. Not spotted; pharyngeal teeth in two rows (1-4-4-1 or 1-4-4-0); eastern and central U. S. to Oklahoma 180.

Body with dark spots; pharyngeal teeth in one row (4-4) 181.

180. Plain silvery colored

Erinemus storerianus (Kirtland) Silver Chub

Hybopsis storerianus (Kirtland)

With a dark band along each side

Hybopsis amblops (Raf.) Bigeye Chub

181. Eye very large, its diameter being more than one-third as long as the head; north-central states

Erimystax dissimilis (Kirtland) Spotted Shiner

Eye small; found in the region between the Mississippi and the Rockies

Macrhybopsis aestivalis (Girard) Speckled Dace

Extrarius aestivalis (Girard)

182. Pharyngeal teeth 6-6 or 6-5; no pseudobranchiae; scale count about 100; over a foot long; California

Orthodon microlepidotus (Ayres) Blackfish

Pharyngeal teeth usually 5-5, 5-4, or 4-4 in the main row; with fewer scales in most species 183.

183. First ray of dorsal fin thickened and separated from the rest by a membrane (often difficult to distinguish); pharyngeal teeth 4-4; scale count usually under 50 184.

First ray of dorsal fin slender and closely attached to the next 187.

184. Peritoneum black; intestine more than twice as long as body; belly often appearing swollen 185.

Peritoneum light; intestine less than twice as long as body; belly usually narrower 186.

185. Lateral line more or less incomplete; with a faint to distinct dark lateral stripe; N. Y. to Texas

Pimephales promelas Raf. Fathead

Lateral line complete; usually with a dark lateral stripe; Dakotas south and east

Hyborhynchus notatus (Raf.) Blunt-nosed Minnow

186. Anal region with dark pigment; with a vertically oval dark spot on the base of the tail fin; Ozark region

Ceratichthys tenellus (Girard) Mountain Minnow

Anal region unpigmented; with a round dark spot on the base of the tail fin; central states to Okla. and Texas

Ceratichthys vigilax B. & G. Bullhead Minnow

Ceratichthys perspicuus (Girard)

(Includes *Cochlognathus ornatus* B. & G.)

187. Lower lobe of tail fin longer than the upper; snout like a pickerel's; pharyngeal teeth 4-5 or 5-5, thick, blunt, scarcely hooked; about three feet long; Cal. and Oregon

Mylopharodon conocephalus (B. & G.) Kaweah Chub, Hardhead

Lobes of tail fin about equal or with the upper slightly longer than the lower; other characters various 188.

188. With a sharp horny plate on each jaw; scale count about 85; pharyngeal teeth 4-5; about a foot long; northwestern U. S.

Acrocheilus alutaceus A. & P. Chiselmouth

Not so 189.

189. Caudal peduncle very long and slender, almost round; pharyngeal teeth 4-5 or 5-5; about a foot long; western species 190.

Caudal peduncle less extreme 192.

190. Scale count about 65; California
Lavinia exilicauda B. & G. Hitch
Scale count about 80; Gila and Colorado Rivers 191.

191. Scales scarcely overlapping, much reduced on back and belly; about a foot long
Gila elegans B. & G. Bony-tail, Gila Trout
Scales slightly overlapping, not so much reduced on back and belly; somewhat larger in the adult
Gila robusta B. & G. Roundtail

192. Snout very long, resembling a pickerel's, with the distance from the eye to the end of the snout more than twice the diameter of the eye; pharyngeal teeth 4-5 or 5-5; very large fishes, getting to be three to five feet long; western species 193.
Snout shorter; size smaller 194.

193. Body slender, more than five times as long as deep; getting to be five feet long; Colorado River Valley
Ptychocheilus lucius Girard White Salmon
Body not so slender; getting to be somewhat over three feet long; Pacific states
Ptychocheilus oregonensis (Richardson) Squawfish, Chappaul

194. Premaxillaries not protractile 195.
Premaxillaries protractile 197.

195. Lips thin; scale count over 60; Maine to Minn. and southwards
Rhinichthys atronasus (Mitchill) Black-nosed Dace
Rhinichthys atratulus (Hermann)
(Includes *R. meleagris* Agassiz)
Lips thick or lobed; scale count less than 60 196.

196. Lips thick but not lobed; eastern states
Parexoglossum laurae Hubbs Eastern Tongue-tied Minnow
Lower lip with a fleshy lobe on each side; N. Y. to Virginia
Exoglossum maxillingua (LeSueur) Cut-lips

197. Lower lip with a fleshy lobe on each side; central states
Phenacobius mirabilis (Girard) Sucker-mouthed Minnow
Lower lip not lobed 198.

198. Intestine wound spirally around the air bladder; ridge of lower jaw separated by a distinct groove from the lower lip; color brownish; N. Y. to Texas
Campostoma anomalum (Raf.) Stone-roller
Intestine not so; ridge of lower jaw usually less set off from lip; color various 199.

199. Herbivorous or mud-eaters; intestine more than twice as long as the body, the contents often visible through the body wall as a dark mass; lining of body cavity usually dark; belly often appearing swollen 200.
Carnivorous; intestine less than two times the body length; lining of body cavity pale in most but not all species; belly usually narrower 206.

200. With two dark stripes along each side; lateral line incomplete or lacking; pharyngeal teeth 4-5 or 5-5; scale count usually over 50 201.
With one or no stripe on side; lateral line complete; pharyngeal teeth 4-4; scale count under 50 204.

201. Stripes on sides not extended to form dark spots on tail; S. D. and Nebraska
Chrosomus dakotensis E. & C.
One or both stripes on each side extended to form a spot on the tail fin 202.

202. Both lateral stripes on each side united on the tail; Susquehanna River southwards
Chrosomus eos Cope
With one stripe on each side extending on to the tail 203.

203. With the lower lateral stripe extending on to the tail; breeding males with red bellies and yellow fins; Colorado to the St. Lawrence River
Chrosomus erythrogaster Raf. Red-bellied Dace
With the upper lateral stripe extending on to the tail; upper Roanoke and Tennessee Rivers
Chrosomus oreas Cope

204. Color greenish, with a dark lateral stripe from snout to tail; no symphyseal protuberance; Illinois to Wyoming and the Ozarks
Dionda nubila (Forbes)
Color gold or silvery, unstriped; with a prominent hard protuberance at the tip of the inside of the lower jaw 205.

205. Sides with a golden sheen; dorsal fin evenly rounded; N. Y. to Montana and southward westerly to Colorado
Hybognathus hankinsoni Hubbs Brassy Minnow
Sides silvery; posterior rays of dorsal fin abruptly shorter than anterior rays; eastern and central states to Texas
Hybognathus nuchalis Agassiz Silvery Minnow
(Includes *H. regius* Girard)

206. Abdomen between the pelvic fins and the anal fin compressed to a keel-like edge, which is unscaled (difficult to see in young specimens); anal rays eleven to fourteen; scale count about fifty; pharyngeal teeth 5-5; six to eight inches long; (fins red in subspecies *crysoleucas*, the eastern form, not red in subspecies *auratus*, the western form); Maine to Texas
Notemigonus crysoleucas (Mitchill) Golden Shiner
Notemigonus auratus Raf.
Abdomen not so; anal rays twelve or less; other characters various 207.

207. Teeth on the pharyngeal bar 4-5 or 5-5 in the main row; scale count usually over 40, often over 50 (35 to 45 in a few species with extremely small mouths or with the lateral line incomplete to absent); size various 208.
Main row of pharyngeal teeth 4-4; scale count less than 60, usually less than 50; lateral line incomplete in a few species; usually small fishes 226.

208. With three pharyngeal teeth in the smaller row; a moderate sized European species introduced into the eastern states

Idus idus Linn. Golden Ide

Pharyngeal teeth in one row or with one or two teeth in the smaller row 209.

209. Mouth extremely small, not extending past a vertical from the nostrils; scale count about 40 210.

Mouth somewhat larger; scale count over 40 in most but not all species 212.

210. Lateral line almost absent; with a distinct black blotch at the base of the tail fin; southern states

Opsopoea bollmani (Gilbert)

Lateral line variously incomplete to complete; black blotch at base of tail fin obscure or absent 211.

211. Lateral line almost complete; usually with a dark lateral stripe, with dark spots above and below; southeastern U. S.

Opsopoeodus emiliae Hay Southern Pug-nosed Minnow

Opsopoeodus emiliae emiliae Hay

Lateral line variously incomplete; sides plain; Great Lakes area to Texas

Opsopoeodus megalops (Forbes) Northern Pug-nosed Minnow

Opsopoeodus emiliae megalops (Forbes)

212. Teeth on the pharyngeal bar in one row; anal rays seven or eight; lateral line incomplete or decurved Roaches 213.

Teeth on the pharyngeal bar in two rows; anal rays seven or more; lateral line various Daces 215.

213. Mouth scarcely oblique; scale count about 54; sides dark spotted or dark striped; about five inches long; Cal. and Nevada

Hesperoleucus symmetricus (B. & G.) Roach

(*Rutilus symmetricus* (B. & G.))

Mouth very oblique; often larger 214.

214. Color plain or spotted; scale count about 56; about a foot long; Cal. and Nevada

Siphateles olivaceus (Cope)

(*Rutilus olivaceus* (Cope))

With a dusky band along each side; scale count about 48; about eight inches long; Oregon and California

Siphateles bicolor (Girard) Roach

(*Rutilus bicolor* (Girard))

215. Lateral line absent or incomplete (do not confuse with lateral band or stripe) 216.

Lateral line complete 219.

216. No trace of lateral line; with a dark lateral stripe; scale count 35 to 40; about an inch and a half long; Utah

Iotichthys phlegethontis (Cope) Little Dace

(*Leuciscus phlegethontis* (Cope))

Usually with some lateral line 217.

217. With scattered dark scales forming a spotted pattern; scale count about 50 to 75; Lake Erie and southwards

Margariscus margarita (Cope) Pearl Minnow

With a dusky or dark band or stripe along each side; scale count not so 218.

218. Scale count about 80; peritoneum black; three inches long; northeastern and north-central states

Pfrille neogaea (Cope) Bronze Minnow

Scale count about 40 to 45; about two and one-half inches long; Tennessee Valley

Hemitremia vittata Cope

219. Lower jaw projecting well beyond the upper; color greenish, with a dark band along each side; males acquiring red coloring in the breeding season; about five inches long; eastern and central U. S. 220.

Jaws almost equal or with the upper longer than the lower; color various; western species 221.

220. Scale count about 50; Atlantic states

Clinostomus vandoisulus (C. & V.) Rosy Dace

Scale count about 70; upper Mississippi Valley area

Clinostomus elongatus (Kirtland) Red-sided Shiner

221. Eye large (head less than four and one-half times as long as the diameter of the eye); anal fin long, often with more than nine rays; adults three to six inches long 222.

Eye smaller in proportion to head; anal fin short, often with less than nine rays; about a foot long 225.

222. Anal rays usually sixteen; with a dark band along each side; breeding males with red coloring; Montana westward

Richardsonius balteatus (Richardson) Red-sided Bream
(*Leuciscus balteatus* (Richardson))

Anal rays usually about eleven; color various 223.

223. Scale count about 80; color olivaceous and silvery; Utah

Cheonda copei J. & G. Leather-sided Minnow
(*Leuciscus copei* (J. & G.))

Scale count 50 to 60 224.

224. With two dark bands along each side, with a reddish one between; Nevada to California

Cheonda egregia (Girard)
(*Leuciscus egregia* (Girard))

With silvery bands along each side, with a red (males) or dark band between; Utah and Idaho area

Cheonda hydrophlox (Cope) Po-he-wa
(*Leuciscus hydrophlox* (Cope))

225. Caudal peduncle about as deep as the head; color brownish, white spotted; California

Siboma crassicauda (B. & G.) Sacramento Chub

Caudal peduncle less deep in proportion to head; color blackish, white spotted; Utah and Yellowstone area (Several species, of which the most widely distributed is given.)

Tigoma atraria (Girard) Great Chub
(*Leuciscus lineatus* (Girard))

226. With the lower portion of the head appearing swollen; mucous channels visible through the operculum as light streaks; scale count about 33; Michigan to Florida and Kansas

Ericymba buccata Cope Silvery-mouthed Minnow

Not so (Over a hundred species of the former genus *Notropis*, the exact identification of which requires dissection and technical knowledge. These are divided into many genera in Jordan, Evermann and Clark's Check List, now mostly restored to the genus *Notropis*. Some of the common species are given here.) 227.

227. Lateral line usually incomplete; with a more or less distinct dark lateral band 228.

Lateral line usually complete 233.

228. Anal rays usually nine to eleven; pharyngeal teeth typically 2-4-4-2; chin black; N. Carolina (If top of head is almost evenly dark, see *N. scepticus* under Choice 259.)

Hydrophlox altipinnis (Cope)
Notropis altipinnis (Cope)

Anal rays usually seven or eight; pharyngeal teeth typically less than 2-4-4-2, except in *N. chalybaeus* 229.

229. Mouth very oblique, with jaws equal; with dark bars on the scales above the lateral line alternating with black spots on the scales of the lateral line to form a zigzag pattern; northern states from N. Y. to N. Dakota

Hybopsis heterodon (Cope) Black-chinned Shiner
Notropis heterodon (Cope)

Mouth less oblique, with the lower jaw slightly shorter than the upper; color not so 230.

230. Dark lateral band passing forward across mouth and chin 231.

Lateral band, consisting of fine dark cross bars across lateral line pores, passing forward just above the mouth 232.

231. Usually with seven rays in the anal fin; north-central states

Hybopsis heterodon richardsoni (H. & G.) Northern Weed
Notropis xaenocephalus richardsoni (H. & G.) Shiner

Usually with eight rays in the anal fin; Mississippi Valley, N. J. to Texas

Hydrophlox chalybaeus (Cope) Ironcolor Shiner
Notropis chalybaeus (Cope)

232. Dorsal fin inserted over pelvic fins; Maine to N. Y. and Virginia

Hybopsis bifrenata Cope Brindled Minnow
Notropis bifrenatus (Cope)

Dorsal fin starting behind beginning of pelvic fins; Mississippi Valley and Great Lakes region

Hybopsis heterolepsis (E. & E.) Blacknose Shiner
Notropis heterolepsis E. & E.

233. Pharyngeal teeth typically less than 2-4-4-2 (1-4-4-2, 1-4-4-1, 1-4-4-0, or 4-4) 234.

Pharyngeal teeth typically 2-4-4-2 251.

234. Anal rays ten or eleven; with a dark band at the base of the dorsal fin; dorsal and tail fin with red color; N. and S. Carolina

Erogala pyrrhomelas (Cope)
(*Notropis pyrrhomelas* (Cope))
Anal rays seven to nine 235.

235. Mouth very oblique; peritoneum black 236.
Not so 237.

236. Lateral stripe obscure; eye very large in head; central states
Hybopsis boops Gilbert Bigeye Shiner
Notropis boops Gilbert
(Includes *H. schumardi* (Gilbert))
Lateral stripe conspicuous; eye less conspicuous; northern states from N. Y. to N. Dakota
Hybopsis anogenus (Forbes) Pugnose Shiner
Notropis anogenus Forbes

237. Anal rays usually seven 238.
Anal rays usually eight or nine 241.

238. Length about three and one-half times depth; pharyngeal teeth 4-4; S. D. to Kansas
Codoma topeka (Gilbert)
Notropis topeka (Gilbert)
Length about five times depth 239.

239. With a fine dark lateral stripe; pharyngeal teeth 4-4; N. Y. to N. Carolina
Hybopsis procne (Cope) Swallowtail Minnow
Notropsis procne (Cope)
Lateral stripe very faint to absent 240.

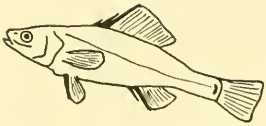
240. Pharyngeal teeth in one row (4-4); dorsal fin beginning before start of pelvics; N. Y. to Minn. and southward to Texas
Hybopsis deliciosa (Girard) Straw-colored Minnow
Notropis deliciosus (Girard)
Pharyngeal teeth 1-4-4-2; dorsal fin above pelvics; N. D. to Penna. and Kansas
Hybopsis blennius (Girard) River Shiner

241. With a dark spot at the base of the tail fin 242.
No dark spot at the base of the tail fin 245.

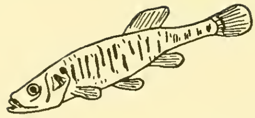
242. Length over five times depth; Tennessee River system
Hybopsis spectrunculus Cope
(*Notropis spectrunculus* (Cope))
Length less than five times depth 243.

243. Dorsal fin plain colored; N. Y. to N. D. and southwards
Hudsonius hudsonius (Clinton) Spottail
Notropis hudsonius (Clinton)
With a dark band at base of the dorsal fin 244.

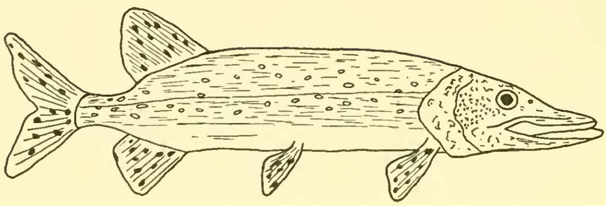
244. Dorsal fin of males red; length four and one-quarter times the depth; Alabama River valley
Erogala trichroistia (J. & G.)
(*Notropis trichroistia* (J. & G.))



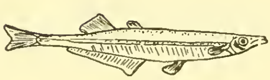
APHREDODERUS SAYANUS



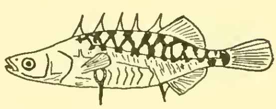
FUNDULUS SP.



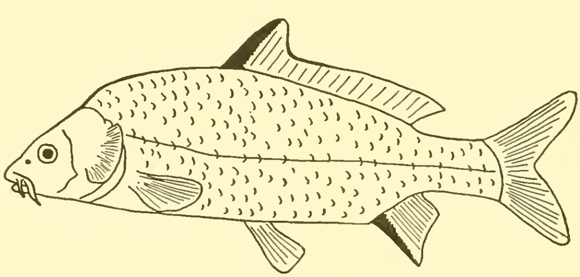
ESOX ESTOR



LABIDESTHES SICCULUS



EUCALIA INCONSTANS



CYPRINUS CARPIO

Fins whitish or yellowish; length four and three-quarters times the depth; Gulf States

Erogala cercostigma (Cope) Spotted Tail

(*Notropis cercostigma* (Cope))

245. With a dark spot or bar on the dorsal fin 246.

Dorsal fin without a dark spot or bar 248.

246. Base of tail fin yellow; south-central states

Erogala galactura (Cope)

Notropis galacturus (Cope)

Not so 247.

247. Usually with nine anal rays; posterior half of dark lateral stripe about midway in depth; central states east of the Alleghenies

Erogala analostana (Girard) Satinfin

Notropis analostanus (Girard)

Usually with eight anal rays; posterior half of dark lateral stripe nearer ventral outline; N. Y. to Minn., southward to Alabama and Arkansas

Erogala whipplii (Girard) Steel-colored Minnow, Spot-fin

Notropis spilopterus (Cope)

248. Depth of body over one-third the length; fins red; S. D. to Illinois and Texas

Moniana lutrensis (B. & G) Redfin

Notropis lutrensis (B. & G.)

Depth of body considerably less in proportion to length 249.

249. Anal rays usually nine; Kansas to Texas

Cyprinella macrostoma Girard

(*Notropis macrostomus* (Girard))

Anal rays usually eight 250.

250. Mouth small, equal to the diameter of the eye; pharyngeal teeth 4-4; N. Y. to Texas

Hybopsis volucella (Cope) Mimic Shiner

Notropis volucellus (Cope)

Mouth larger; pharyngeal teeth 1-4-4-1; N. Y. to Colorado

Hybopsis gilberti (J. & M.) Bigmouth Shiner

Notropis dorsalis (Agassiz)

251. Dorsal outline of head raised so that the eye is about equi-distant between the dorsal and ventral margins; color plain, pale; Rio Grande

Orcella orca (Woolman)

(*Notropis orca* Woolman)

Eye slightly nearer the dorsal than the ventral margin; color various 252.

252. With 23 to 30 scales before the dorsal fin 253.

With less than 23 scales before the dorsal fin 256.

253. Dorsal fin over pelvic fins; states east of the Rockies except the south Atlantic and Gulf states

Luxilus cornutus (Mitchill) Northern Common Shiner

Notropis cornutus frontalis (Agassiz)

Dorsal fin behind area over pelvic fins 254.

254. No dark spot on dorsal fin; with two black crescents between nostrils; length about five and one-half times depth; Mich. to N. Carolina
Notropis photogenis (Cope) Silvery Minnow
With a dark spot on the dorsal fin; length about four to four and one-half times depth 255.

255. With a dark spot on the upper part of the front of the dorsal fin; fins red; Gulf states
Lythrurus roseipinnis (Hay) Southern Redfin
(*Notropis roseipinnis* Hay)
With a dark spot at the base of the dorsal fin; fins red; N. Y. to Minn. and southward to Arkansas
Lythrurus umbratilis (Girard) Northern Redfin
Notropis umbratilis (Girard)

256. With a dark spot at the base of the tail fin 257.
No dark spot at the base of the tail fin 264.

257. Usually with ten or eleven rays in the anal fin 258.
Usually with seven to nine rays in the anal fin 261.

258. No dark band across middle of dorsal fin 259.
With a dark band across middle of dorsal fin 260.

259. Length about five times depth; sides silvery, with scales dark edged; east-central states to the Ozarks
Notropis micropteryx (Cope)
Length about four times depth; with a dark stripe along each side; chin and top of head dark (If top of head before eyes has light coloring, see *N. altipinnis* under Choice 228.); Carolinas
Notropis scepticus (J. & G.)

260. With a horizontal dark band on dorsal fin; blue above, with some red on fins and cheeks; length about three and one-half times depth; Georgia area
Coccotis zonistius (Jordan)
(*Notropis zonistius* (Jordan))
With an oblique dark band on dorsal fin; brown above, with a reddish stripe along each side; length about five times depth; Georgia and Florida
Notropis metallicus J. & M.

261. With a red stripe along each side; fins with red bars; Alabama Valley
Hydrophlox chrosomus (Jordan)
(*Notropis chrosomus* (Jordan))
Lateral stripe obscure or purplish 262.

262. Anal rays seven; fins of male red; Gulf States
Hydrophlox roseus (Jordan) Rosy Fin
(*Notropis roseus* (Jordan))
Anal rays usually eight 263.

263. Lateral stripe obscure; fins pale; length four to four and one-half times depth; N. Y. to N. D. and southwards
Hudsonius hudsonius (Clinton) Spottail
Notropis hudsonius (Clinton)

With a purplish band along each side; base of dorsal fin red in males; length about five times depth; Tennessee Valley
Notropis leuciodus (Cope)

264. Usually with ten rays in the anal fin; dorsal fin starting above posterior end of base of pelvic fins 265.
Usually with seven to nine rays in the anal fin; dorsal fin starting above pelvic fins 266.

265. Lateral band obscure; eye about as long as snout; length about five and one-half times depth; Great Lakes, south and west
Notropis atherinoides Raf. Emerald Shiner
Lateral band dark posteriorly; snout longer than eye; length somewhat less than five times depth; N. Y. to Kansas
Notropis rubrifrons (Cope) Rosy-faced Minnow
Notropis rubellus (Agassiz)

266. Lower jaw projecting; no distinct dark lateral bands 267.
Jaws about equal 268.

267. Outer half of dorsal fin dark; length slightly less than four and one-half times depth; Cumberland region
Coccotis coccogenis (Cope)
(*Notropis coccogenis* (Cope))
Fins plain; length slightly more than four and one-half times depth; Virginia
Coccotis macdonaldi (J. & J.)
(*Notropis macdonaldi* J. & J.)

268. Usually with seven rays in the anal fin; with a silvery stripe along each side; Penna. to Kansas
Paranotropis jejunus (Forbes)
(*Notropis jejunus* (Forbes))
Usually with nine rays in the anal fin 269.

269. No red color; with about fifteen scales before the dorsal fin; length four and one-half to five times depth; Ohio and Tennessee Valleys
Paranotropis ariommus (Cope)
(*Notropis ariommus* (Cope))
Males with much red coloring; with fifteen to twenty-two scales before the dorsal fin; length three and one-half to four and one-half times depth 270.

270. Mouth rather large, with maxillary reaching to a point beyond front of eye; with a dark stripe along each side; Tennessee and Savannah Rivers
Hydrophlox rubricroceus (Cope) Red Fallfish
(*Notropis rubricroceus* (Cope))
Mouth smaller, maxillary not reaching eye; peritoneum black 271.

271. With a fine dark stripe between the broad lateral stripe and the mid-dorsal band; young with two dark crescents between nostrils; Ozark region
Coccotis zonatus (Agassiz) Striped Minnow
(*Notropis zonatus* (Agassiz))
Dark stripes and bands less distinct; no dark crescents between nostrils;

area east of the Rockies except extreme northern U. S.

Luxilus cornutus chrysocephalus (Raf.) Central Common Shiner

Notropis cornutus chrysocephalus (Raf.)

272. With two to eleven free spines before the dorsal fin; Family *Gasterosteidae* Sticklebacks 273.

With spines contained in the anterior part of the dorsal fin or in a finlet preceding it 276.

273. With seven to eleven free spines before the dorsal fin; north Atlantic coast and Great Lakes region

Pungitius pungitius (Linn.) Nine-spined Stickleback

With two to six free spines before the dorsal fin 274

274. With small bony plates on the sides; ascending streams from the Atlantic and Pacific

Gasterosteus aculeatus Linn. Common Stickleback

(Includes *Gladiunculus bispinosus* (Walbaum))

No such plates 275.

275. With three free dorsal spines; north Atlantic coast

Apeltes quadracus (Mitchill) Four-spined Stickleback

With four to six free dorsal spines: N. Y. to Kansas, in fresh water

Eucalia inconstans (Kirtland) Brook Stickleback

276. With one or two spines in the anterior end of the dorsal fin 277.

Dorsal fin with an anterior spinous portion containing four or more (rarely three) spines 284.

277. Outline of tail convex; Florida (a killifish, Family *Cyprinodontidae*)

Jordanella floridae G. & B. Florida Killifish

Tail fin forked 278.

278. With one dorsal spine, which is strongly serrate behind; this spine may or may not be preceded by a smooth spine; adult fishes eight inches or more long; introduced species which have become established in ponds and streams; Family *Cyprinidae* (part) 279.

Dorsal spine double, the posterior one fitting into a groove in the anterior one; very small fishes; mostly confined to the southwest (Colorado, Nevada and Arizona); Family *Medidae* 281.

279. With two barbels on each side of the upper jaw; an introduced Asiatic species, which has become well established

Cyprinus carpio Linn. Carp

No barbels; an introduced genus common in pet shops and frequently becoming large and established from escapes; adults gold or remaining greenish throughout life 280.

280. Scale count twenty-seven or less; with seven or eight rays in the anal fin

Carassius auratus (Linn.) Japanese Goldfish

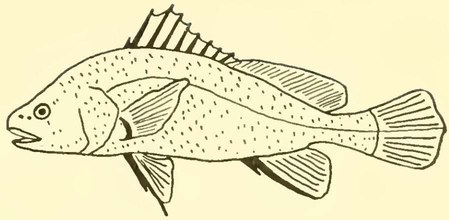
Scale count twenty-eight or more; with five or six soft rays in the anal fin

Carassius carassius (Linn.) European Goldfish

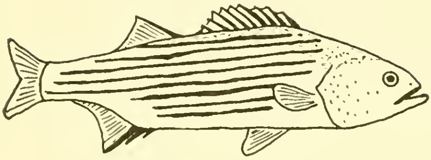
281. Body with scales 282.

Body scaleless 283.

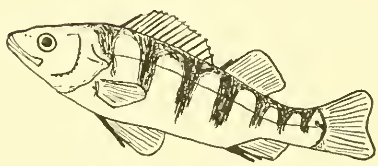
BOLEOSOMA NIGRUM



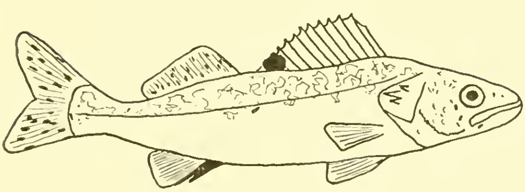
APLODINOTUS GRUNNIENS



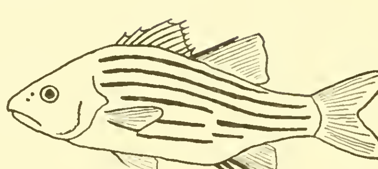
ROCCUS SAXATILIS



PERCA FLAVESCENS



STIZOSTEDION VITREUM



CHRYSOPERCA INTERRUPTA

282. Mouth almost horizontal
Lepidomeda jarrovii Cope
Mouth oblique
Lepidomeda vittata Cope

283. With a small barbel at each corner of the mouth
Plagopterus argentissimus Cope
No maxillary barbels
Meda fulgida Girard

284. Body scaleless or with bony plates; Family *Cottidae* Sculpins 285.
Body scaled 295.

285. Gill membranes almost free from the isthmus (fleshy part between the gill openings), making a fold across it; spinous portion of dorsal fin well in advance of soft portion; in deep water of some of the Great Lakes
Triglopsis thompsoni Girard Lake Sculpin
With a wide isthmus between the gill membranes, with no fold across it; spinous and soft dorsal fins adjacent 286.

286. In the eastern and central states, northwestward through Minnesota 287.
In the western states 289.

287. Lateral line complete; Great Lakes area
Cottus ricei (Nelson)
Lateral line incomplete; northeastern and north-central states 288.

288. No teeth on the palatine bones (in roof of mouth); usually evenly mottled
Cottus gracilis Heckel Miller's Thumb, Rock Cusk
Cottus cognatus gracilis Heckel
With teeth on the palatines; with dark mottlings, often forming vertical bars on the sides
Cottus ictalops (Raf.) Miller's Thumb, Toe-biter
Cottus bairdii Girard

289. With teeth on the palatine bones (in roof of mouth); preopercle with one large spine turned upwards and two or three smaller spines turned downwards below it 290.
No teeth on the palatines; preopercle with one large spine at its tip 292.

290. With 12 to 14 rays in the anal fin; Rocky Mountain region
Cottus semiscaber (Cope) Rocky Mountain Bullhead
With 15 to 18 rays in the anal fin; Pacific coastal streams 291.

291. Anus more than halfway back from end of snout to base of tail fin; seven inches long in the adult
Cottus gulosus (Girard) Rifflefish
Anus halfway between end of snout and base of tail fin; getting to be a foot long
Cottus asper Richardson Prickly Bullhead

292. Posterior nostrils with tubes; dorsal fins connected 293.
No tubes in posterior nostrils; dorsal fins not connected 294.

293. Lateral line incomplete; Klamath Lakes, Oregon

Cottus klamathensis Gilbert Klamath Muddler
Lateral line practically complete; Pacific States
Cottus aleuticus Gilbert Coast Sculpin

294. With a mottled pattern; Colorado Valley
Cottus annae J. & S. Colorado Muddler
With dark cross bars; Columbia Valley
Cottus beldingii E. & E. Columbia Muddler

295. With two dorsal fins distinctly separate from each other, or else small fishes, under three inches, with the body depth less than one-fourth the length 296.
With one dorsal fin, sometimes with the spiny portion almost separated from the soft portion by a deep notch, but retaining some connection 357.

296. Pelvic fins abdominal; seldom over three and one-half inches long; Family *Atherinidae* Silversides (many marine species) 297.
Pelvic fins jugular or thoracic 298.

297. Jaws long and flat, like a pickerel's; N. Y. to Florida and Texas
Labidesthes sicculus (Cope) Brook Silversides
Jaws not so; mouth small; in fresh and brackish waters of the Atlantic and Gulf coasts
Menidia beryllina (Cope) Silverside

298. Lateral line absent or almost so 299.
Lateral line more or less complete 304.

299. Tail fin slightly emarginate; not over two inches long; in fresh water; Family *Etheostomidae* (part) Darters 300.
Tail fin rounded or pointed; usually in brackish water or in fresh water near the coast 302.

300. With one anal spine; Arkansas to Texas
Alvarius fonticola J. & G. Midget Darter
With two anal spines 301.

301. Cheeks scaly; Alabama and Mississippi
Microperca proeliaris Hay
Cheeks not scaly; Arkansas to Minn. and Michigan
Microperca punctulata Putnam Least Darter
Microperca microperca (J. & G.)

302. Pelvic fins separate; adults one to two feet long; southern Atlantic and Pacific coasts; Family *Eleotridae* (species mostly marine)
Dormitator maculatus (Bloch) Striped Sleeper, Guavina
Pelvic fins united; usually only a few inches long; Family *Gobiidae* Gobies (many marine species) 303.

303. Scales minute, inconspicuous, smooth edged; California
Eucyclogobius newberryi (Girard)
Scales larger, rough edged; Gulf coast
Rhinogobius shufeldti (J. & E.)
(*Gobius shufeldti* J. & E.)

304. With three or more spines in the anal fin (anterior spine often minute);

body fairly deep, lengthwise striped; Family *Moronidae* (part) River Bass 305.
With not more than two spines in the anal fin 306.

305. With seven or eight stripes on each side; Atlantic slope; introduced into California
Roccus saxatilis (Walbaum) Striped Bass
With five or six stripes on each side; Mississippi Valley
Lepibema chrysops (Raf.) White Bass
(*Roccus chrysops* (Raf.))

306. Preopercle finely serrate behind and below; belly evenly scaled; adults ten inches or more; Family *Percidae* Perch 307.
Preopercle not serrate, or else with the belly unevenly scaled; small, seldom reaching eight, more often about three inches; Family *Etheostomidae* Darters (About a hundred species, only the most common of which are given here) 310.

307. Body fairly deep; no canine (longer conical) teeth; sides with dark bars; eastern and north-central states
Perca flavescens (Mitchill) Yellow Perch
Body elongate and almost cylindrical; canine teeth present; sides mottled 308.

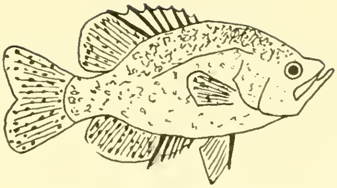
308. With rows of dark spots on both dorsal fins; usually with a dark blotch at the base of the pectoral fin; cheeks closely scaled; posterior dorsal fin with 17 to 20 rays; northern states
Cynoperca canadensis (Smith) Sauger, Sand Pike
Stizostedion canadense (Smith)
Anterior dorsal fin with a large black spot on the posterior part; no dark blotch at the base of the pectoral fin; cheeks sparsely scaled; posterior dorsal fin with 19 to 22 rays 309.

309. Body yellow mottled; lower fins yellow; eyes almost as far apart as the diameter of one eye; Great Lakes region, south and east
Stizostedion vitreum (Mitchill) Wall-eyed Pike, Pike-perch
Stizostedion vitreum vitreum (Mitchill)
Body grayish; lower fins bluish; eyes much closer together; Great Lakes region
Stizostedion glaucum Hubbs Blue Pike
Stizostedion vitreum glaucum Hubbs

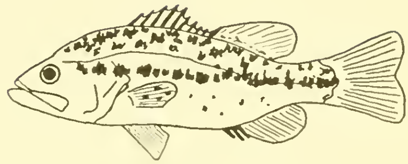
310. Belly partly scaleless or with scales on the mid-ventral line larger than those on the rest of the body, plate-like, or sometimes shed, leaving a bare area 311.
Belly scales not noticeably different from the rest 327.

311. Premaxillaries protractile, usually with a groove between them and forehead; dorsal spines 7 to 11 312.
Premaxillaries not protractile; no groove between them and forehead; dorsal spines 10 to 15 317.

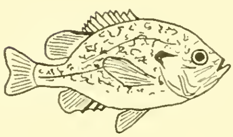
312. Body elongate; depth one-eighth to one-tenth the length; dorsal spines 7 to 10 313.
Body deeper; dorsal spines 9 to 11 315.



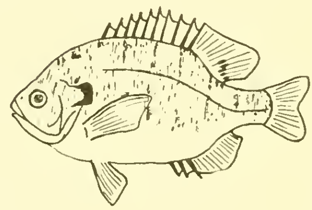
POMOXIS SPAROIDES



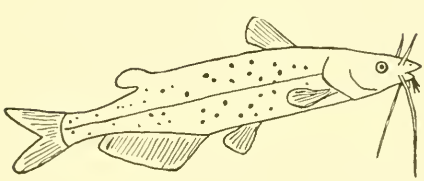
HURO FLORIDANA



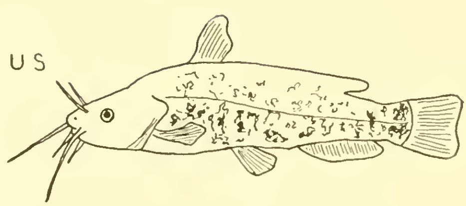
EUPOMOTIS GIBBOSUS



HELIOPERCA INCISOR



ICTALURUS PUNCTATUS



AMEIURUS NEBULOSUS

313. With two spines in the anal fin; Maryland, Virginia and N. C.
Ioa vitrea (Cope)
With one spine in the anal fin 314.

314. Sides of body poorly scaled; Gulf States
Ammocrypta beanii Jordan Sand Darter
Sides of body more or less regularly scaled; Mississippi Valley to Texas
Vigil pellucidus (Baird) Sand Darter

315. Cheeks scaled; Michigan to Kentucky and Arkansas
Imostoma shumardi (Girard) Shumard's Darter
Cheeks not scaled 316.

316. With four dark bars on the back and with several smaller dark blotches along each side; Ind. to Ala. and Arkansas
Cottogaster uranidea (J. & G.)
Brownish above; each side with a continuous series of dark blotches; N. Y. to Missouri
Cottogaster copelandi (Jordan) Copeland's Darter

317. With one soft anal spine; body depth one-seventh to one-eighth of length; scale count over 80; with several dark bars across back and a dark band made up of a series of blotches along each side; Ind. to Ala. and Arkansas
Crystallaria asprella (Jordan)
With two anal spines (anal spines soft in *P. caprodes*); other characters various 318.

318. Head broad; space between the eyes more than one-fifth the length of the head; snout much overhanging mouth; scale count about 90; with dark upright bars on the body and a dark spot at the base of the tail fin; west to Texas
Percina caprodes (Raf.) Log-perch, Hogfish
Head narrower, with the space between the eyes smaller; mouth almost terminal; scale count less in most but not all species; color various, many of the species having confluent dark blotches along the sides Black-sided Darters 319.

319. Pelvic fins about as far apart as the base of one pelvic fin 320.
Pelvic fins closer together 325.

320. Gill membranes well connected with each other across the isthmus; cheeks well scaled; spinous dorsal fin with an orange band just within margin, this fin separated from the soft dorsal about the width of the eye; Ohio to Oklahoma
Alvordius phoxocephalus (Nelson) Slender-headed Darter
Hadropterus phoxocephalus (Nelson)
Gill membranes scarcely connected; cheeks somewhat less scaled to bare 321.

321. Dorsal spines 13 to 15; dorsal fins almost contiguous; scale count usually over 58 322.
Dorsal spines 11 or 12; dorsal fins various; scale count usually under 65 323.

322. Cheeks and opercles scarcely scaled; Penna. southwards
Alvordius macrocephalus (Cope) Big-headed Darter
(*Hadropterus macrocephalus* (Cope))
Cheeks and opercles scaled; north-central states
Alvordius maculatus Girard Black-sided Darter
Hadropterus maculatus (Girard)
(*Hadropterus aspro* (C. & J.))

323. Pectoral fins shorter than the head, scarcely reaching opposite tips of pelvics; Penna. to S. Carolina
Alvordius peltatus (Stauffer) Shielded Darter
(*Hadropterus peltatus* (Stauffer))
Pectoral fins about as long as the head, reaching to tips of pelvics or further 324.

324. Dorsal fins almost contiguous; with much yellow in coloring; with an orange band across first dorsal fin; Virginia to N. Carolina
Alvordius roanoka (J. & J.) Roanoke Darter
(*Hadropterus roanoka* J. & J.)
Dorsal fins separated by about the diameter of the eye; color plainer; upper fins light and dark barred; Ind. to Arkansas
Alvordius ouachitae (J. & G.) Ouachita Darter
(*Hadropterus ouachitae* (J. & G.))

325. Gill membranes not joined; with about ten rays in second dorsal fin; no palatine teeth; color yellow, with dark markings; upper fins orange; N. Y. to N. C. and Oklahoma
Ericosma evides (J. & C.) Gilt Darter
Hadropterus evides (J. & C.)
Gill membranes united across the isthmus; usually with more than ten rays in second dorsal fin; with palatine teeth 326.

326. Preopercle with fine serrations behind; color yellowish, with dark markings; upper fins dark; Ind. to Texas
Serraria sciera (Swain)
(*Hadropterus scierus* Swain)
Preopercle smooth edged; color dark greenish, with dark markings; S. C. to Louisiana
Hadropterus nigrofasciatus Agassiz Crawl-a-bottom

327. Lateral line noticeably incomplete (usually over nine pores missing) 328.
Lateral line almost complete (less than seven pores missing) 343.

328. Premaxillaries protractile (usually with a groove between them and forehead); head flattened and depressed behind the eyes 329.
Premaxillaries not protractile; no groove between them and forehead; head compressed and elevated behind the eyes 330.

329. With one anal spine; sides dark mottled; with dark bars on dorsal and tail fins; Ind. to Texas
Vaillantia camura (Forbes) Blunt-nose Darter
Boleosoma chlorosomum (Hay)
With two anal spines; with W-shaped markings along the sides; first dorsal fin with an orange band; Georgia to Tenn. and Arkansas
Ulocentra stigmaea (Jordan) Speck
(*Doration stigmaea* (Jordan))

330. With one anal spine 331.
With two spines in the anal fin 332.

331. Dorsal fins with nine or ten spines and eleven to thirteen rays; head scaled; Alabama
Psychromaster tuscumbia (G. & S.) Tuscumbia Darter
Dorsal fins with seven or eight spines and eight to ten rays; head bare; Ark. to Texas
Alvarius fonticola J. & G.

332. Gill membranes broadly joined across the isthmus (fleshy part between the gill openings); usually with an enlarged black scale on the shoulder 333.
Gill membranes scarcely connected 334.

333. Lower jaw projecting much beyond the upper; colors rather plain; dorsal spines of male with fleshy knobs at their tips; New England to N. C. and Arkansas
Catonotus flabellaris (Raf.) Fan-tailed Darter
Poecilichthys flabellaris (Raf.)
Jaws about equal; with red or orange spots on sides and with bands on the fins; no fleshy knobs on dorsal spines; Arkansas valley
Claricola whipplii (Girard) Whipple's Darter
(*Poecilichthys whipplii* (Girard))

334. Lateral line arched upwards anteriorly; first dorsal fin over three-fourths height of second dorsal fin 335.
Lateral line fairly straight; dorsal fins various 339.

335. Shortest distance from lateral line to mid-dorsal area about one-fifth depth of body 336.
Shortest distance from lateral line to mid-dorsal area about one-sixth depth of body 337.

336. Lateral line ending below first dorsal fin, which has a broad orange band; with an orange lateral band on body; N. Y. to Colorado
Oligocephalus iowae (J. & M.) Iowa Darter
Poecilichthys exilis (Girard)
Lateral line ending below second dorsal fin; first dorsal fin with a fine orange line; body colors plainer; Michigan to Texas
Oligocephalus jessiae (J. & B.) Jessie's Darter
Poecilichthys jessiae J. & B.

337. Parietals (on top of head behind eyes) scaled; body dark brown and green; southeastern U. S.
Hololepis barratti Holbrook
Parietals scaleless 338.

338. Gill membranes little connected; breeding males with a red band on first dorsal fin; Indiana to Texas
Boleichthys gracilis (Girard)
Hololepis gracilis (Girard)
Gill membranes somewhat more connected; with yellow rather than red in coloration; eastern states
Boleichthys fusiformis (Girard) Fusiform Darter
Hololepis fusiformis (Girard)

339. No enlarged black scale on shoulder; first dorsal fin over three-fourths height of second dorsal fin; cheeks blue; sides with blue and orange bars; fins blue and orange 340.
Usually with an enlarged black scale on the shoulder (at base of pectoral fin); first dorsal fin often lower 341.

340. Gill membranes very slightly connected; males with red coloring on anal and tail fins; N. Y. to Minn. and southward in the Mississippi Valley almost to the Gulf
Oligocephalus caeruleus (Storer) Rainbow Darter
Poecilichthys caeruleus (Storer)
Gill membranes slightly overlapping anteriorly; no red coloring on anal and tail fins; Mich. to Virginia and Kansas
Poecilichthys spectabilis Agassiz Orange-throat Darter

341. Scale count usually over 60; gill membranes not connected; belly red; Ozark area
Nivicola punctulata (Agassiz)
(*Poecilichthys punctulatus* Agassiz)
Scale count usually less than 60; gill membranes very slightly connected 342.

342. With small dark spots along the middle of each side; fins with reddish coloring; Colorado and Kansas to the Rockies
Nivicola cragini (Gilbert) Cragin's Darter
(*Poecilichthys cragini* (Gilbert))
Sides almost plain except for very fine dots and mottling; no red or blue coloring; Ind. to Florida
Claricola squamiceps (Jordan)
(*Poecilichthys squamiceps* (Jordan))

343. Head flattened and depressed behind the eyes 344.
Head compressed and elevated behind the eyes 352.

344. Premaxillaries more or less protractile (protractile downwards, groove not evident from above, in *E. blennioides*); anal fin with one or two spines and six to nine rays 345.
Premaxillaries not protractile (no groove between them and forehead); anal fin with two spines and ten to twelve rays 349.

345. With one soft spine in anal fin; usually with eight or nine dorsal spines; snout moderately sharp; color usually brownish, often with M or W-shaped lateral markings 346.
With two spines in anal fin; usually with ten to fourteen dorsal spines; snout blunt; color mostly greenish, with dark lateral bands extending down from a dark dorsal area or with more or less diamond shaped markings 347.

346. Cheeks scaly; second dorsal fin with fine dark markings; eastern and central states to Colorado
Boleosoma nigrum (Raf.) Johnny Darter
Boleosoma nigrum nigrum (Raf.)
Cheeks without scales; second dorsal fin with dark bands; east of the Allegheny southward to N. Carolina
Boleosoma olmstedi (Storer) Tessellated Darter
Boleosoma nigrum olmstedi (Storer)

347. Profile very convex; with twelve to fourteen spines in the first dorsal fin; N. Y. to Kansas
Etheostoma blennioides Raf. Green-sided Darter
Profile not so convex; usually with less than twelve spines in the first dorsal fin 348.

348. Operculum scarcely scaled; dorsal fin barred; Ind. to Arkansas
Ulocentra histrio (J. & G.)
Operculum scaled; dorsal fin spotted; Kentucky southwards
Ulocentra simotera (Cope)

349. Gill membranes broadly connected across the isthmus; Tennessee Valley
Swainia squamata (G. & S.)
Gill membranes scarcely connected 350.

350. Operculum and breast bare; males with red coloring; Ozark region
Hypohomus nianguae (G. & M.) Niangua Darter
Poecilichthys nianguae (G. & M.)
Operculum and breast with small scales 351.

351. With a row of dark blotches joined along each side; dorsal spines fifteen; Tennessee Valley
Hypohomus aurantiacus (Cope)
With two light streaks with darker color between along each side; dorsal spines twelve to fourteen; Missouri
Hypohomus cymatotaenia (G. & M.)

352. Gill membranes broadly joined across the isthmus; pelvic fins well separated 353.
Gill membranes scarcely or not joined; pelvic fins close together 354.

353. Anal fin about as large as the soft dorsal fin; Ohio Valley
Poecilichthys variatus (Kirtland)
Anal fin much smaller than the soft dorsal; central states (Several species, of which the most widely distributed is given)
Nanostoma zonale (Cope) Banded Darter
Poecilichthys zonalis Cope

354. No scales on the operculum; brilliantly colored fishes with the fins dark edged; Illinois to Penna. and N. Carolina
Nothonotus camurus (Cope) Blue-breasted Darter
Poecilichthys camurus Cope
With scales on the operculum 355.

355. With dark cross bands; shoulder with a large dark scale; Alabama
Nothonotus jordani (Gilbert) Jordan's Darter
(*Poecilichthys jordani* (Gilbert))
Coloration spotted or striped; no large dark scale on the shoulder 356.

356. Usually with more than 55 scales in the lateral line; fins not red bordered; Ala. to Ohio and Indiana
Nothonotus maculatus Kirtland
(*Poecilichthys maculatus* Kirtland)
Usually with less than 50 scales in the lateral line; fins red bordered; Cumberland, Tennessce and Green Rivers

Nothonotus rufilineatus (Cope)
(*Poecilichthys rufilineatus* Cope)

357. With sixteen to eighteen dorsal spines 358.
With less than fourteen dorsal spines 359.

358. Spinous portion of the dorsal fin higher than the soft portion; California; Family *Embiotocidae* (About twenty species, mostly marine)
Hysterocarpus traski Gibbons Surf-fish
Spinous portion of dorsal lower than the soft portion; Rio Grande Valley; Family *Cichlidae* (Many tropical species)
Herichthys cyanoguttatus B. & G. Cichlid
(*Heros cyanoguttatus* (B. & G.))

359. Lateral line pores extending on to the tail fin; Great Lakes to Texas; Family *Sciaenidae* (Many marine species)
Aplodinotus grunniens Raf. Sheephead, Drum, Thunderpumper
Lateral line pores not extending on to the tail fin 360.

360. Spinous portion of dorsal fin almost disconnected from, and equal to or higher than, the soft portion 361.
Spinous portion of dorsal fin confluent with or lower than the soft portion 363.

361. Mouth very large, reaching below the back of the eye in the adult; with a broken dark band along each side; Great Lakes to Texas; introduced into many other localities; Family *Centrarchidae* (part)
Huro floridana (LeSueur) Large-mouthed Black Bass, Green Trout
Micropterus salmoides (Lacépède)
Mouth smaller, reaching below the front of the eye; sides plain or with six or seven dark stripes; Family *Moronidae* (part) 362.

362. With six or seven black stripes, interrupted posteriorly; lower Mississippi Valley
Chrysoperca interrupta (Gill) Yellow Bass
Morone interrupta Gill
No dark stripes; Atlantic Slope
Morone americana (Gmelin) White Perch

363. No lateral line; outline of tail convex; less than two inches long; Family *Elassomidae* 364.
Lateral line half or more complete; tail various; size various; Family *Centrarchidae* Sunfishes and Basses 365.

364. Scale count more than 34; Ill. to Ala. and Texas
Elassoma zonatum Jordan Pigmy Sunfish
Scale count less than 34; Georgia and Florida
Elassoma evergladei Jordan Everglades Pigmy Sunfish

365. With five to eight anal spines; dorsal fin somewhat elongate, but not twice as long as anal 366.
With three (rarely four) spines in the anal fin; dorsal fin more elongate, often more than twice as long as the anal 371.

366. Dorsal spines five to eight 367.
Dorsal spines ten to fourteen 368.

367. Dorsal spines usually six; distance from eye to dorsal fin definitely longer than base of dorsal fin; body with dark spots arranged in bars; Great Lakes to Texas, and introduced into many other localities
Pomoxis annularis Raf. White Crappie, Sac-a-lait
Dorsal spines usually seven or eight; distance from eye to dorsal fin about equal to base of dorsal fin; body with dark spots; Great Lakes to Florida and Texas; introduced on the Pacific Slope and elsewhere
Pomoxis sparoides (Lacépède) Calico Bass, Black Crappie
Pomoxis nigro-maculatus (LeSueur)

368. Dorsal fin only slightly longer than the anal; anal spines seven or eight, anal rays fifteen; small, becoming six inches; sides with lengthwise rows of dark spots; southeastern states and lower Mississippi Valley
Centrarchus macropterus (Lacépède) Round Sunfish, Flier
Dorsal fin decidedly longer than the anal; anal spines five to seven, anal rays ten 369.

369. Tail fin convex in outline; anal spines five; small, becoming six inches; sides obscurely striped; Atlantic Slope
Acantharchus pomotis (Baird) Mud Sunfish
Tail fin emarginate; anal spines six or seven; larger 370.

370. Sides with lengthwise rows of dark spots; getting to be a foot long; New England south and west to Arkansas
Ambloplites rupestris (Raf.) Rock Bass, Redeye
Sides with dark bars; getting to be almost two feet long; California
Archoplites interruptus (Girard) Sacramento Perch

371. Outline of tail convex; two to five inches long; Atlantic Slope 372.
Tail emarginate or forked 374.

372. With ten somewhat graduated spines in the dorsal fin, the fourth and fifth definitely longer than the eighth, ninth and tenth; pectoral fins reaching about to the front of the anal fin; about four inches long; N. J. to Maryland
Mesogonistius chaetodon (Baird) Black-banded Sunfish
With nine dorsal spines, the fourth and ninth about equal; pectoral fins reaching back about to the middle of the anal fin 373.

373. Black spot on the operculum more than one-half the size of the eye; about five inches long in the adult; Mass. to Florida
Enneacanthus obesus (Girard) Little Bream
Black opercular spot less than one-half the size of the eye; not over three inches long; N. Y. to Florida
Enneacanthus gloriosus (Holbrook) Blue-spotted Sunfish

374. Depth usually less than two-fifths the length (not including the tail fin) in the adult; operculum with two blunt points behind; mouth reaching under or behind the eye; adults two feet or more long Basses 375.
Depth seldom less than two-fifths the length in the adult; operculum with an unnotched flap behind; mouth large or small; small to moderately sized fishes; often brilliantly colored Sunfishes 378.

375. Dorsal fin with a deep notch; mouth extending to a point slightly behind the eye in adult specimens; soft dorsal and anal fins not scaly; with a

broken dark band along each side; Great Lakes to Texas; widely introduced elsewhere
Huro floridana (LeSueur) Large-mouthed Black Bass
Micropterus salmoides (Lacépède) Green Trout

Dorsal fin with a slight notch; mouth not extending behind the eyes; soft dorsal and anal fins scaly near base 376.

376. With dark spots forming an obscure dark band along each side; south-central states, north to Ohio; introduced elsewhere
Micropterus pseudoplites Hubbs Kentucky or Spotted Black Bass
Micropterus punctulatus (Raf.)

Sides with faint barring 377.

377. With fine dark lengthwise streaks on lower part of each side; lobes of tail fin scarcely barred; Alabama and Georgia
Micropterus coosae Hubbs & Bailey Redeye Bass

No fine dark lengthwise streaks so situated; lobes of tail fin dark barred in young; west to Oklahoma
Micropterus dolomieu Lacépède Small-mouthed Black Bass

378. Mouth extending to below the rear margin of the eye; with teeth on the tongue; west to Texas and the Dakotas
Chaenobryttus gulosus (C. & V.) Warmouth Bass
Chaenobryttus coronarius (Bartram)

Mouth usually smaller; no teeth on the tongue 379.

379. Lateral line extending about halfway back; tail fin very slightly emarginate; scale count about 35; not over three inches long; Ill. to La. and Texas
Apomotis symmetricus (Forbes) Little Sunfish
(*Lepomis symmetricus* Forbes)

Lateral line almost or quite complete; tail fin distinctly emarginate or forked; scale count greater in most, but not all, species; size various 380.

380. With one or two small dark spots on each scale; gill rakers about half as long as the gill filaments; scale count 45 to 55; S. Carolina to Florida
Apomotis punctatus (C. & V.) Spotted Bream
(*Lepomis punctatus* (C. & V.))

Color not so; other characters various 381.

381. Dark opercular spot situated on the bony part of the operculum; pectoral fins much rounded; mouth rather large, almost to below the middle of the eye; color usually greenish, with a small light spot on each scale; Great Lakes region to the Rio Grande
Apomotis cyanellus (Raf.) Green or Blue-spotted Sunfish
Lepomis cyanellus Raf.

Dark opercular spot largely on the soft flap extending back from the operculum; not with the preceding combination of other characters 382.

382. Black spot on the operculum longer than the eye in adult specimens; length of longest dorsal spine about one and one-quarter times the diameter of the eye; gill rakers on the first gill arch very short and stumpy, about one-fifth as long as the gill filaments 383.

Black opercular spot not longer than the eye; length of longest dorsal spine one and one-half to two times the diameter of the eye; gill rakers various 385.

383. Opercular spot usually deeper than the eye; gill rakers soft; pectoral fins pointed; Michigan to Minn., south to S. C. and Texas; introduced elsewhere

Xenotis megalotis (Raf.) Long-eared Sunfish, Sun Perch
(*Lepomis megalotis* (Raf.))

Opercular spot usually not as deep as the eye; gill rakers stiff; pectoral fins broadly rounded 384.

384. With a dark blotch on the posterior end of the dorsal fin; lower fins yellow; Virginia to Louisiana

Lepomis solis (C. & V.) Southern Long-eared Sunfish

No dark blotch on the dorsal fin; lower fins red; Maine to Virginia

Lepomis auritus (Linn.) Yellow-bellied or Eastern Long-eared Sunfish

385. Gill rakers long and slender, about one-half as long as the gill filaments; opercular bone (not flap) pliable behind 386.

Gill rakers shorter and stouter; opercular bone stiff behind 387.

386. With a diffuse black blotch on the lower half of the last four or five rays of the dorsal fin; operculum scarcely light margined behind; sides dark barred; Great Lakes to Florida and the Rio Grande; introduced elsewhere

Helioperca incisor (C. & V.) Bluegill
Lepomis macrochirus Raf.
(*Lepomis pallidus* of many writers)

No black blotch so situated; with three-quarters of the opercular spot on the soft flap, the other quarter made up of the greenish or dark hard point of the operculum; opercular flap light margined behind, often tinged with red; sides with orange spots; not over three and one-half inches long; Dakotas to Alabama and Texas

Allotis humilis (Girard) Orange-spotted Sunfish
Lepomis humilis (Girard)

387. Opercular flap scarcely light margined behind; pectoral fins shorter than head; with teeth on vomer and palatines (in roof of mouth); sides with rows of squarish orange spots; lower Mississippi Valley

Sclerotis miniatus (Jordan) Scarlet Sunfish, Stump Perch
(*Lepomis miniatus* (Jordan))

Opercular flap orange or red bordered; pectoral fins as long as or longer than head; no teeth on palatines; sides spotted to plain 388.

388. With a definite red spot on the opercular flap (faded to yellowish in preserved specimens); cheeks with greenish stripes; Atlantic States, Great Lakes region and upper Mississippi Valley

Eupomotis gibbosus (Linn.) Pumpkinseed
Lepomis gibbosus (Linn.)

Opercular flap orange or red margined behind; cheeks less definitely striped 389.

389. Usually with 42 or more scales in the lateral line, and with six or seven rows between the lateral line and the dorsal fin; Virginia to Florida

Eupomotis holbrookii (C. & V.) Strawberry Bass, Eastern Shellcracker

Lepomis microlophus (Günther)

Usually with 40 or less scales in the lateral line, and with four or five rows of scales between the lateral line and the dorsal fin; Ill. to Florida and Texas

Eupomotis heros (B. & G.) Western Shellcracker, Redear Sunfish

Lepomis microlophus (Günther), subspecies

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The names used as first choice in the fish key are those given in the Check List by Jordan, Evermann and Clark. In accordance with our general policy we have used the latest available check list for our first choice of names. There is, however, some disagreement among experts in fish taxonomy concerning the validity of some of these names (See Copeia — 1935, No. 4, Pages 196-197). The unbracketed names given as second choice are used in much of the current literature.

SALAMANDERS

Chapter 9

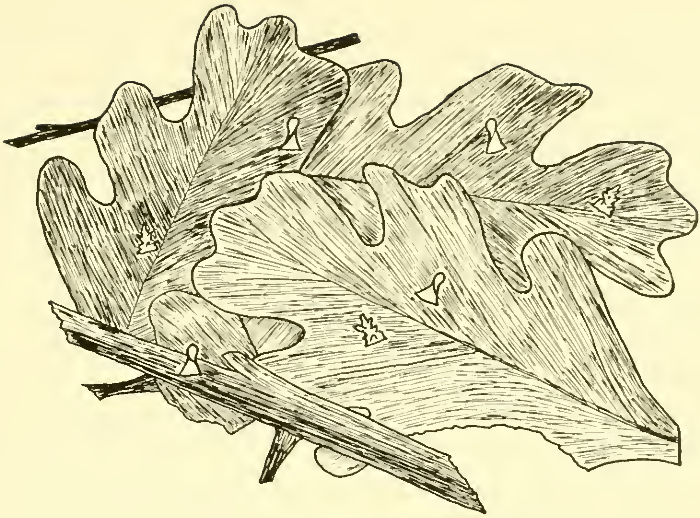
Salamanders have long held a place in popular superstition. The famous fire salamander of Europe is reputed to have such an asbestos constitution that it seeks out the heart of a fire in which to bask. The author once had a practical demonstration of the way in which this superstition may have arisen. Having used some old fence rails for a campfire, he was surprised to see several of the common red-backed salamanders, *Plethodon cinereus,* hastily emerging from the fissures of the rails as the fire burned. Needless to say, the salamanders lost no time in leaving the scene, since, unlike lizards, they carry on much of their respiration through the skin, which must be kept moist.

The nature of the skin is one of the best distinguishing characteristics between salamanders and lizards. Most salamanders have moist, scaleless skins, while all but a few degenerate members of the lizard group have dry, scaly skins. In regions where lizards are scarce or unknown, the term "lizard" is commonly misapplied to the local salamanders.

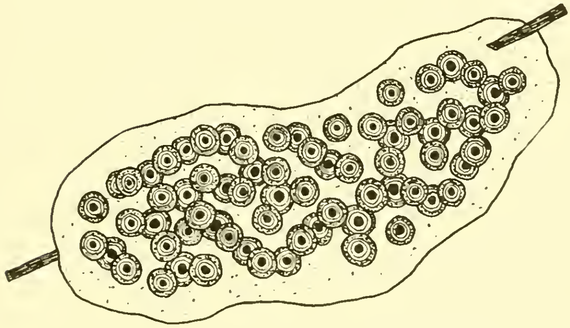
Although limited to moist situations, salamanders have become adapted to a variety of habitats. Even in cave pools and artesian wells they are sometimes found, usually as blind or colorless forms. The European salamander of the genus *Proteus* has been frequently described and pictured in textbooks. Several equally modified or degenerate forms are found in America. In large streams and rivers may be found our largest or giant salamanders, such as *Necturus, Cryptobranchus* and *Amphiuma,* the latter reaching a length of about three feet. The only close relative of *Cryptobranchus,* found, strangely enough, in China and Japan, is the largest of living salamanders and reaches the imposing length of five feet. In muddy lakes of the southern states occurs the siren, an eel-like salamander that has lost all vestiges of hind legs and retains only a very small pair of front legs. In swift mountain brooks may be found the genera *Desmognathus, Eurycea, Pseudotriton, Gyrinophilus* and others. In order to maintain themselves in the swiftly flowing water, these forms have given up their buoyant lungs and, in the adult, carry on respiration through the skin and the lining of their mouths. In quiet ponds with much submerged vegetation live the newts of the genus *Triturus,* the common species of which are attractive, red-spotted, greenish or brownish animals with flattened tails and large hind feet. Usually these newts spend much of their second year of life on land, as red efts, but return to the water and to a more somber color for their adult life. Some salamanders have taken up a terrestrial existence, although most of them are still restricted to damp situations. Those of the genus *Ambystoma* migrate to the ponds for egg-laying, but the *Plethodons* are completely emancipated and pass even their larval stages on land. The tree salamander, *Aneides lugubris*, a native of California, is our only truly arboreal salamander, with habits of climbing trees and making homes in their cavities.

Details of reproduction vary in different forms. A few foreign species bring forth living young. Most of the *Ambystomidae* lay masses of pigmented eggs in water, each egg having one or more gelatinous envelopes and the whole bunch having a common envelope. The egg-laying usually occurs in the spring, but the marbled salamander, *Ambystoma opacum*, lays its eggs in the autumn, under the moss and leaves of areas which will be the floors of temporary ponds in the spring. Hatching is delayed until favorable conditions arrive. Many of the *Plethodontidae* lay at the edge of the water or on land, usually under moss or rocks in damp locations. Their eggs are usually without pigment and are suspended individually by slender, gelatinous stalks. The tree salamander, *Aneides lugubris*, often lays its eggs in the cavity of the tree it uses for a retreat. Members of this family and some of the others have been reported as brooding, or at least staying by, their developing eggs. It is possible that by doing so they aid in maintaining the proper conditions of moisture, but it seems probable in many cases that the eggs are deposited in the usual retreat of each female, which it continues to use after the eggs have been laid. The latter idea seems a likely explanation of reports of brooding by such an aquatic form as *Necturus*, unless it may possibly stay by its eggs to protect them from destruction by other aquatic animals. The common newt deposits its eggs separately, usually wrapping each in the leaf of some water plant. *Triturus torosus*, the California newt, lays its eggs in small bunches much like those of the *Ambystomidae*. The giant salamanders, *Amphiuma, Cryptobranchus* and *Necturus*, deposit unpigmented eggs in water. The first two lay numbers of eggs connected by slender strings of jelly. *Necturus* suspends its eggs separately from the under sides of submerged rocks or logs. One of the *Ambystomidae, Ambystoma tigrinum*, the tiger salamander, may under certain conditions remain in the larval stage and reproduce without losing its gills and transforming into the typical adult form. This peculiar stage is called the axylotl, the name by which it is known (and eaten) by the natives of Mexico. The mudpuppies (of the family *Necturidae*) are forms in which this condition of arrested development in everything but reproduction has become firmly established. A few of the *Plethodontidae* also retain gills and other larval characteristics throughout life.

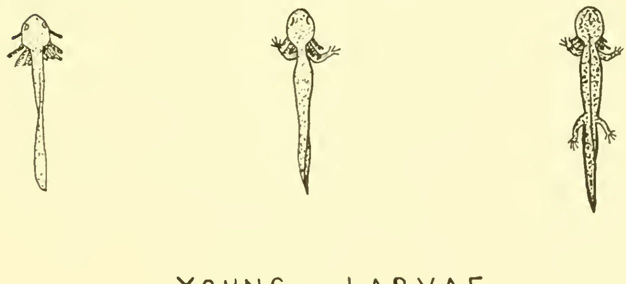
For purposes of illustration it seems best to give a more extended account of the reproduction and development of one of the most commonly studied salamanders, *Ambystoma maculatum*. Because of the great variation of breed-



SPERMATOPHORES OF A. MACULATUM ON VEGETATION OF POND BOTTOM



EGG MASS



YOUNG LARVAE

ing habits among salamanders, the actions of this form cannot be considered typical of the group. A discussion of its behavior may, however, familiarize the reader with generalized salamander development. This animal, commonly known as the spotted salamander, breeds in the spring—about the first of April in our northeastern states. It spends its adult life on land, except during the breeding season. As soon as the ground thaws sufficiently in the spring, great numbers of these animals travel by night to the ponds to breed. A warm rain will greatly speed up and concentrate this spring migration. Often the males enter the ponds somewhat before the females. The former deposit small, whitish, cone-like objects with gelatinous bases and tips of sperm, known as *spermatophores,* on the submerged vegetation. These are not usually deposited, however, until after the arrival of the females and are usually associated with courtship or *Liebesspiel.* During the courtship activity, which occurs at night, the male rubs the top of the head against the ventral surface of the female, usually starting at the cloacal region and working forwards toward the throat. At frequent intervals the male moves away to deposit a spermatophore on nearby vegetation. The female finally becomes sufficiently excited to approach a spermatophore, placing her cloaca above it. At this time some of the sperm from the tip of the spermatophore enter the cloaca of the female. This behavior may be repeated several times. The eggs are usually not laid for several hours thereafter. They are deposited in masses averaging fifty to one hundred eggs per bunch, each female averaging two or three bunches. The egg masses are attached to submerged sticks or growing vegetation a few inches below the surface of the water. The period of migration and egg-laying usually lasts about two or three weeks, after which the salamanders return to a terrestrial life. The eggs take about ten days or two weeks to hatch, the speed of development being directly proportional to the temperature of the water. The very young larvae have "balancers" on the head and are without legs. The gills are present from hatching time until transformation. Presently, as the balancers disappear, the front legs grow, then the hind legs. The young feed voraciously upon small aquatic animals, being particularly fond of wood frog tadpoles. About three or four months usually elapse before metamorphosis, this period also varying with the temperature of the water. Gradually the head becomes more pointed and the gills begin to disappear. The young salamanders seek the edge of the water. Later they crawl out of the water altogether and finally take up an adult terrestrial existence.

Most salamanders produce skin secretions that lubricate the surface of the body or prove distasteful or irritating to their enemies. From this habit arose the popular belief that salamanders are poisonous to the touch, an erroneous idea as applied to our native species. Many salamanders shed the skin periodically, some in small pieces, others as whole, transparent sheets. An entire shed skin, floated in water, shows the perfect outlines of the body, even to the tiny, glove-like hands and feet. The common newt, like some of the other salamanders, eats the skin immediately after it is shed, shaking it vigorously from side to side as it is engulfed.

Salamanders are chiefly carnivorous, snapping greedily at small moving objects when hungry. The larvae will eat each other, if they are much crowded. Newts do not hesitate to attack small fish, biting at their eyes and fins, and are also clever at extracting frog eggs from the jelly envelopes that baffle almost all other enemies. The terrestrial salamanders feed largely upon earthworms, snails and insects.

Most salamanders can be easily kept in captivity, although all but the newts are too shy to be very entertaining. They do well in tilted tanks, with sphagnum or other moss at the water-line, where they usually gather. Most forms require little food if they are kept in a cool, shaded place, a few *Drosophila* or other insects once or twice a week usually sufficing them. Newts and the giant salamanders are greedy feeders, however, and require worms or morsels of raw meat every day or two.

Salamanders are best preserved for scientific purposes by drowning them in strong (70-95%) alcohol and then transferring them, within half an hour, to five per cent formalin. They regain and keep their original plumpness, if so treated. For aid in identification it is advisable to prop their mouths somewhat open while they are still flexible.

While many field and experimental studies have been made, there remain many interesting problems. A few are suggested here.

DISTRIBUTION This is especially interesting, since the salamanders seem very poorly equipped for migrations of any great extent and completely barred by salt water and arid land barriers. Yet we find such peculiar distributions as that of *Cryptobranchus,* confined to the eastern United States, and the form which most closely resembles it, *Megalobatrachus,* found in China and Japan. E. R. Dunn's introduction to *The Salamanders of the Family Plethodontidae* contains an excellent critique of the usual criteria for determination of place of origin and paths of dispersal. The study of local distribution also affords a good lesson in adaptation. Most localities within the United States harbor several genera of salamanders, each usually so well fitted to its particular type of habitat that it comes into little or no competition with the others. Brook, river, pond, lake and forest each have their forms, some well adjusted to live their whole lives in one area, others still making somewhat of a pilgrimage to find different conditions in which their larvae can develop.

LIFE HISTORIES Much remains to be discovered about the life histories of many of our salamanders. Where and under what conditions do they hibernate? How long does it take them to reach maturity? What factors govern their choice of a breeding site? How long does the breeding season last? What is their courtship behavior? Even such an apparently minor question as the last has been shown by the late G. K. Noble to throw much light on the relationship of species.

EMBRYOLOGY Since egg-laying can often be induced by pituitary implants, it is possible to follow the embryological development at other times than the normal mating season. Even gross studies are of value. Correlations between temperature and other environmental conditions and the rate of development can be determined. Presence of balancers and their degree of development at hatching time, size and form of external gills, and development of limbs are characters by which one might be able to identify eggs and larvae at different ages. All these should be determined and recorded for each species.

A survey of the technical characters which separate families and genera of salamanders will reveal that most of the distinctions are based on the skeleton. If serious study of the group is intended, the student should master the technique of the alizarin bone stain and the potash clearing methods. A brief account of the structural characters used in the key follows.

HEAD

The members of one family, *Plethodontidae,* are unique in possessing a *naso-labial groove* running from each nostril vertically to the mouth. On the adult this is plainly visible, since there is no pigment along its course. Its function is apparently to drain the water quickly from the nasal area as the animal emerges from the water, probably a matter of importance to a lungless animal which uses its mouth for respiration (bucco-pharyngeal respiration). Two genera, *Desmognathus* and *Leurognathus,* have the lower jaw rigid, the mouth being opened by lifting the upper jaw and head. This stiffness apparently enables the animal to push its way more readily under rocks and debris. It also gives the animal a characteristic profile, of aid in identification. The attachment of the tongue varies in different forms, some having it attached at the front, some at the back, and some with a median attachment, both ends being free. The patches of teeth on the roof of the mouth are also important in taxonomy. The diagrams should be consulted and the location and different arrangements of *vomerine* or *vomero-palatine* and *parasphenoid* teeth noted. Below the chin a fold of skin, the *gular fold,* is present in some groups.

BODY

Along the sides of the body and tail of many of the salamanders a number of folds or line-like, vertical depressions may be seen. These mark the positions of the ribs and are called *costal grooves.* The number of these on each side between the fore and hind limbs, including those directly at the point of attachment of the limbs, often aids in determining the identity of a salamander.

LIMBS

The number of fingers and toes sometimes aids in identification. *Necturus*, for example, has four toes while the axylotl, which sometimes much resembles it, has five. The thickened pads on hand and foot, *palmar* and *plantar tubercles*, vary in different species. Some of the specialized forms show varying degrees of webbing of the toes.

TAIL

In general, the more aquatic species have flattened or finned tails, the more terrestrial ones have more cylindrical tails. The terrestrial species sometimes show a constriction area at the base of the tail, which usually indicates the ability of the animal to snap off its tail when threatened, the twitching tail often serving as a decoy while its owner slips quietly away. A tail so lost is gradually replaced, but the second is seldom as well developed.

COLOR

There is much variation in color pattern, both between individuals and in the same individual during its growth. Spotted or plain colored adults may have striped or barred larvae. Young mudpuppies (*Necturus maculosus*) show lengthwise stripes, young of the black Jefferson and narrow-mouthed salamanders, *Ambystoma jeffersonianum* and *Ambystoma texanum*, have a distinct pattern of cross bars. The young of *Eurycea* may go through a bewildering series of spotted or striped markings before assuming adult coloration. The adults of some species show great variation. *Ambystoma tigrinum*, the tiger salamander, varies from mostly black to mostly yellow. The common newt, *Triturus viridescens viridescens*, has a greenish water stage and a red land stage. In preserved specimens red color usually disappears completely and yellows and blacks fade considerably. The key is based on average adult specimens.

OUTLINE OF CLASSIFICATION OF NATIVE SALAMANDERS

Order CAUDATA (or *Urodela*) of Class AMPHIBIA

Tail retained throughout life; pectoral and pelvic girdles unspecialized

Suborder PROTEIDA

Family NECTURIDAE

With external gills throughout life; no maxillary; short series of teeth on premaxillary; complete row of teeth on vomero-palatine and pterygoid; with four digits on each limb

One genus—*Necturus* (7 species) Mudpuppies

Suborder MUTABILIA

Family AMPHIUMIDAE

One pharyngeal gill slit on each side; limbs present but much reduced; not over three digits on each limb; row of teeth on vomer paralleling those on the maxillary

One genus—*Amphiuma* (1 species) Congo Snakes

Family CRYPTOBRANCHIDAE

Body flattened, wrinkled; one pharyngeal gill slit on each side (in native species); limbs well developed; row of teeth on vomer paralleling those on the maxillary

One genus—*Cryptobranchus* (2 species) Hell-bender

(One other genus, *Megalobatrachus,* is found in Asia)

Family SALAMANDRIDAE (or *Pleurodelidae*)

Teeth on diverging posterior extensions of the vomero-palatines, which extend over the parasphenoids; no parasphenoid teeth

One genus—*Triturus* (7 species) Newts

Family AMBYSTOMIDAE

With one transverse row of vomero-palatine teeth; no parasphenoid teeth

Three genera — *Dicamptodon* (1 species)
Rhyacotriton (1 species)
Ambystoma (12 species)

Family PLETHODONTIDAE

With naso-labial grooves; large patches of teeth on parasphenoid

Seventeen genera —

Desmognathus (5 species)
Leurognathus (1 species)
Plethodon (17 species)
Ensatina (3 species)
Hemidactylium (1 species)
Plethopsis (1 species)
Batrachoseps (2 species)
Aneides (4 species)
Haideotriton (1 species)
Stereochilus (1 species)
Typhlotriton (1 species)
Typhlomolge (1 species)
Gyrinophilus (4 species)
Pseudotriton (2 species)
Eurycea (8 species)
Manculus (1 species)
Hydromantes (1 species)

Suborder MEANTES

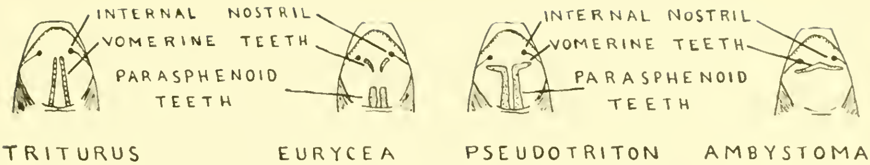
Family SIRENIDAE

Body elongate, snake-like; no hind limbs; front limbs much reduced; premaxillary and dentary with horny sheaths; large patches of teeth on vomer

Two genera — *Siren* (2 species) Sirens
Pseudobranchus (1 species) Striped Siren

KEY TO THE PRINCIPAL SPECIES OF SALAMANDERS

1. With but one pair of legs; aquatic; Family *Sirenidae* 2.
   With two pairs of legs in the adult 4.



ROOF OF MOUTH

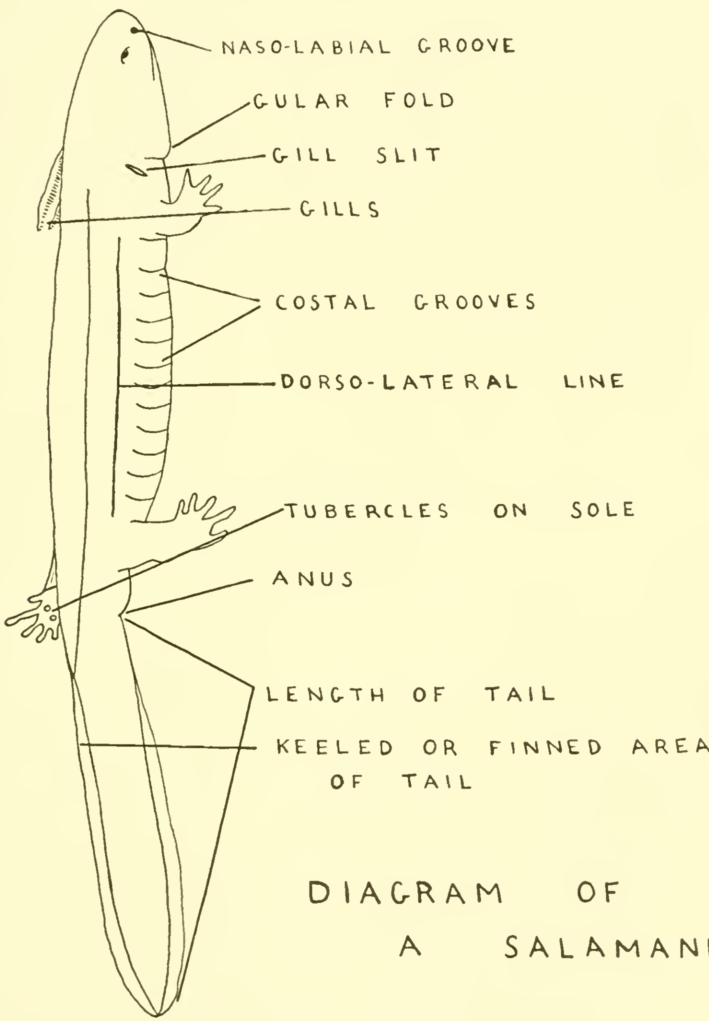


DIAGRAM OF A SALAMANDER

2. With three toes on each foot; sides lengthwise striped; about six to eight inches long; in swamps of S. C., Georgia and Florida
Pseudobranchus striatus (Le Conte) Little Striped Siren
With four toes on each foot; color plain; larger 3.

3. With 31 to 36 costal grooves; adults usually from twelve to eighteen inches long; Ill. to Florida and Texas
Siren intermedia Le Conte Dwarf Siren
With 36 to 39 costal grooves; adults often over two feet long; Florida north to D. C.
Siren lacertina Linn. Giant Siren, Mud Eel

4. Adults with external gills 5.
Adults without external gills 11.

5. Body white; blind forms found in wells and caves; Family *Plethodontidae* (part) 6.
Body usually pigmented; eyes developed 7.

6. Gills very long, reaching back to well behind the insertion of the fore limbs; from a well at Albany, Georgia
Haideotriton wallacei Carr Georgia Blind Salamander
Gills shorter; from artesian wells and cave streams of Texas
Typhlomolge rathbuni Stejneger Texas Blind Salamander

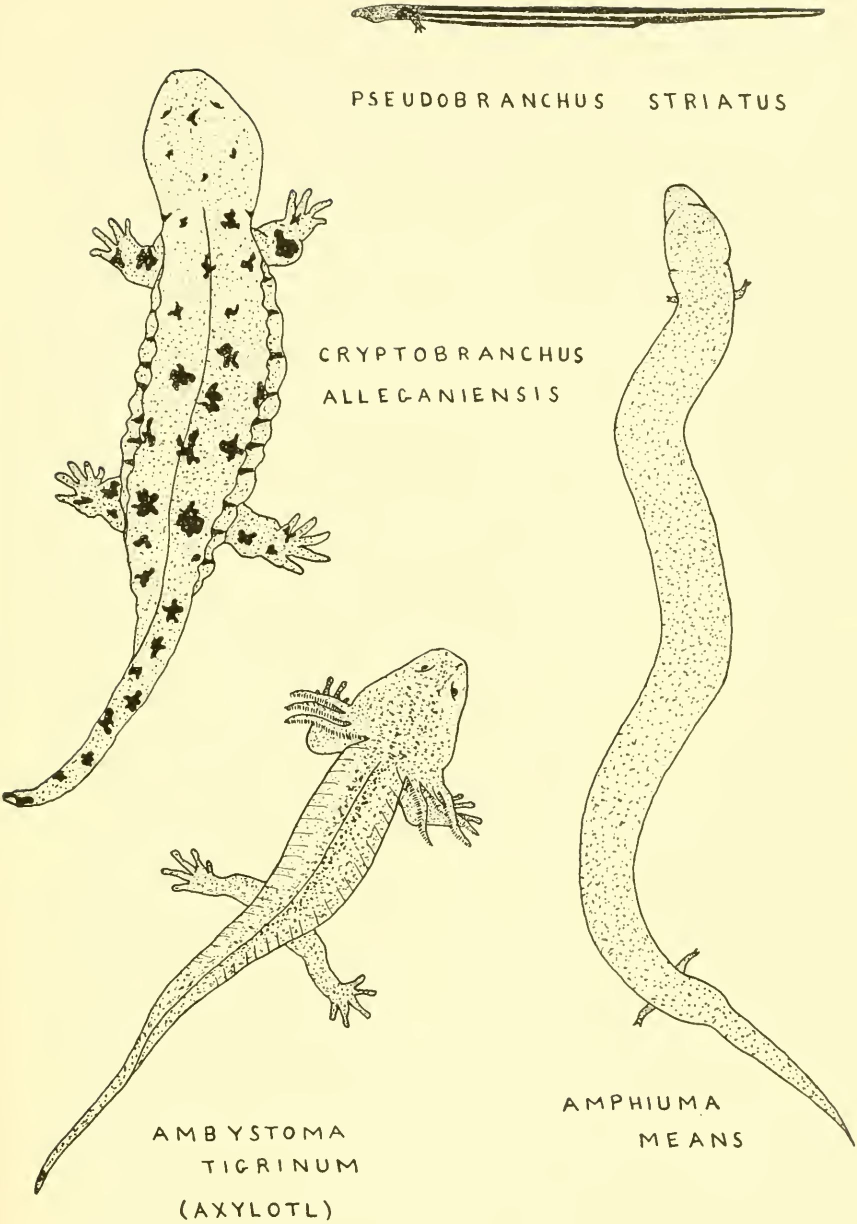
7. With four toes on the hind foot; with three pairs of bushy, red gills; aquatic; adults about six to eighteen inches long; Family *Necturidae* (*Proteidae*) (Seven species, of which the four most common and widely distributed are given here) 8.
With five toes on the hind foot; gills not so; aquatic or terrestrial; often smaller 14.

8. Back uniformly dark colored or with a few light spots; belly mostly without spots; Carolinas and Georgia
Necturus punctatus (Gibbes) Carolina Waterdog
(*Menobranchus punctatus* Gibbes)
Back with dark spots or markings; belly with or without spots 9.

9. Tail strongly keeled, deeper than body; with a wide dark bar from nostril through eye on each side of head; young with dorsal stripes; adults spotted above; adults about ten to seventeen inches long; eastern and central states
Necturus maculosus (Raf.) Common Mudpuppy, Waterdog
(*Necturus maculatus* (Raf.))
Tail less strongly keeled; dark bar through eye narrower, indistinct, or not reaching nostril; both young and adults spotted above; adults about six to ten inches long; southeastern states 10.

10. Back and belly fairly evenly colored and regularly spotted with scattered dark spots; N. Carolina
Necturus lewisi (Brimley) Lewis's Mudpuppy
Back and belly distinctly different in appearance, the belly usually lighter colored or with smaller dark spots; Florida to Louisiana
Necturus beyeri Viosca Southern Mudpuppy

11. Body eel-like; legs very small and weak, with two or three toes on each


PSEUDOBRANCHUS STRIATUS
CRYPTOBRANCHUS ALLEGANIENSIS
AMPHIUMA MEANS
AMBYSTOMA TIGRINUM (AXYLOTL)

foot; about thirty-five inches long; aquatic; Family *Amphiumidae* 12.
Body less extreme; with more toes on each foot 13.

12. With two toes on each foot; southeastern states
Amphiuma means means Garden Congo Snake or Eel, Blind Eel
With three toes on each foot; Missouri and Kentucky to Louisiana and Florida
Amphiuma means tridactylum Cuvier Three-toed Congo Snake

13. Body heavy and much depressed, with a conspicuous, wrinkled fold of skin along each side; about two feet long; aquatic; Family *Cryptobranchidae*
Cryptobranchus alleganiensis (Daudin) Hell-bender
No folds of skin so situated; smaller 14.

14. Costal grooves (vertical creases along the sides of the body between the fore and hind limbs) absent or almost so; vomerine teeth (on roof of mouth) in two long convergent or nearly parallel, lengthwise rows; no parasphenoid teeth; Family *Salamandridae* Newts 15.
Costal grooves present; teeth not so 22.

15. Back uniformly brown to black; West Coast 16.
Back greenish, brownish, or orange-red, usually with spots or stripes; east of the Rockies 18.

16. Back very dark brown to black; belly red; eyes dark brown; northern California
Triturus rivularis Twitty Red-bellied Newt
Back variously brown; belly yellow or orange; eyes not so 17.

17. Vomerine teeth in a V-shaped pattern, diverging posteriorly; California northward through Oregon
Triturus granulosus (Skilton) Oregon Newt
Vomerine teeth in two nearly parallel rows, bent abruptly sideways posteriorly; California
Triturus torosus (Rathke) Giant California Newt (and related species)

18. With a broken or entire red stripe along each side of back 19.
Not so 20.

19. Red stripes bordered with black; N. and S. Carolina
Triturus viridescens dorsalis (Harlan) Carolina Newt
(*Triturus viridescens symmetrica* (Harlan))
Red stripes often dusky but not definitely black bordered; Georgia and Florida
Triturus perstriatus Bishop Striped Newt

20. With black-edged red spots in a row on each side of the back (water stage has back greenish, land stage red or orange); west to Illinois and south to Georgia
Triturus viridescens viridescens (Raf.) Common Newt or Red Eft (Land stage)
(*Diemyctylus viridescens* of Cope)
Spots plain red or black 21.

21. With black spots dorsally; Texas
Triturus meridionalis (Cope) Black-spotted Newt
With small black dots and scattered reddish spots dorsally; Wis. to Florida and Texas
Triturus viridescens louisianensis (Wolterstorff) Louisiana Newt

22. With an exceedingly fine, unpigmented groove (or sometimes apparently a ridge) running from nostril to mouth almost vertically; with a gular fold; with parasphenoid teeth; Family *Plethodontidae* 23.
No naso-labial grooves; often lacking a gular fold; no parasphenoid teeth; vomerine teeth running crosswise or slightly obliquely; Family *Ambystomidae* 89.

23. Tongue attached at the anterior margin 24.
Tongue free at the anterior margin (attached in the middle) 65.

24. A blind, white, cave form found in Missouri and Kansas to Oklahoma
Typhlotriton spelaeus Stejneger Cave Salamander
With functional eyes; pigmented 25.

25. Hind foot with four toes only 26.
Hind foot with five toes, one of which may be very small 29.

26. With fourteen costal grooves; with a row of black spots on each side of belly; eastern and central states
Hemidactylium scutatum (Schlegel) Eastern Four-toed Salamander
With sixteen or more costal grooves; West Coast 27.

27. Toes half webbed; body moderately stout; Oregon
Plethopsis wrighti Bishop Wright's Four-toed Salamander
Toes scarcely or not webbed; body worm-like 28.

28. Belly finely and evenly reticulated with black; with a light mid-dorsal stripe; West Coast
Batrachoseps attenuatus (Eschscholtz) Western Worm Salamander
Belly unevenly black dotted; mid-dorsal stripe faint to absent; California
Batrachoseps pacificus (Cope) California Worm Salamander

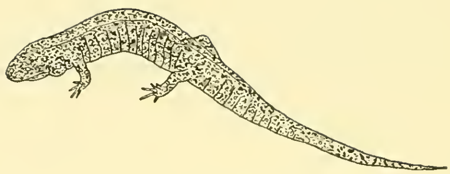
29. With two tubercles on the palm of each front foot; tail constricted at base; with eleven to thirteen costal grooves; West Coast 30.
No tubercles on palms; tail not constricted at base; with eleven to twenty-one costal grooves 33.

30. Back uniformly brownish above; West Coast
Ensatina eschscholtzii eschscholtzii Gray Western Red Salamander
Back irregularly colored 31.

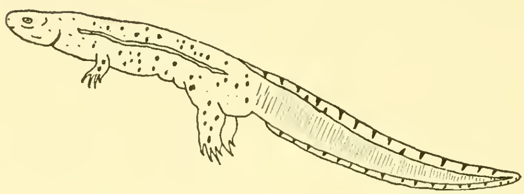
31. Back light brownish, with darker spots and markings; Cal. and Oregon
Ensatina eschscholtzii picta Wood Western Painted Salamander
Back dark brown to black, with yellow spots or blotches 32.

32. With large yellow blotches on back, often joined above to form cross bands; tail barred above; legs yellow; Cal.
Ensatina croceater (Cope) Western Yellow-barred Salamander

EURYCEA LONGICAUDA GUTTOLINEATA

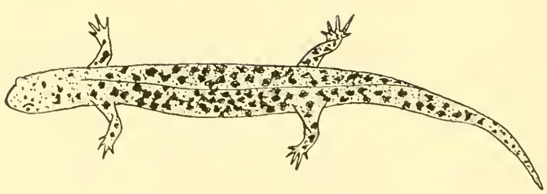


DESMOGNATHUS FUSCUS AURICULATUS



TRITURUS VIRIDESCENS DORSALIS

ANEIDES LUGUBRIS



PSEUDOTRITON RUBER RUBER

With smaller, irregular, yellow blotches along sides; back and tail less definitely barred; legs yellow, with dark blotching; Cal., in the Sierras
Ensatina sierrae Storer Sierra Marbled Salamander

33. Lower jaw immovable, the mouth being opened by lifting the top of the head 34.
Lower jaw moving in the normal fashion 42.

34. No light line from eye to mouth; nostril openings into the roof of the mouth inconspicuous and twice as far apart as the external nostrils; color usually blotched; N. Carolina and Tenn.
Leurognathus marmorata Moore Moore's Salamander
With a light line from the eye to the corner of the mouth; internal nostrils conspicuous and about the same distance apart as the external nostrils; color various 35.

35. Tail cylindrical or squarish along most of length 36.
Tail compressed or triangular, narrow above 38.

36. Front corner of upper eyelid not grooved; with a dark bar through eye to nostril; belly light colored; light dorsal band variably irregular; Mts. of N. C., Tenn. and Virginia
Desmognathus wrighti King Wright's Desmognathus
Front corner of upper eyelid grooved; belly often darker, or light dorsal band with smooth edges 37.

37. Belly faintly pigmented; light dorsal band, if present, with smooth edges; northern Appalachian Mountains
Desmognathus ochrophaeus ochrophaeus (Cope)
Allegheny Salamander
Belly quite dark; light dorsal band, if present, with irregular edges; southern Appalachian Mountains
Desmognathus ochrophaeus carolinensis Dunn
Carolina Mountain Salamander

38. Belly practically plain colored 39.
Belly finely mottled or speckled 40.

39. Belly very dark; mountains from Vir. to Georgia
Desmognathus quadramaculatus (Holbrook) Black-bellied Desmognathus
Belly light; mountains from Penna. to Georgia
Desmognathus phoca (Matthes) Seal Salamander

40. Belly dark, mottled or speckled with white; Virginia to Florida and Miss.
Desmognathus fuscus auriculatus (Holbrook) Southern Dusky Salamander
Belly light, usually finely mottled or speckled with dark 41.

41. Typically with a lighter dorsal band and without light spots along the sides; west to Illinois
Desmognathus fuscus fuscus (Raf.) Dusky Salamander
Typically with the dorsal band obscure to absent and with light spots along the sides; Ark. to Texas and Okla.
Desmognathus fuscus brimleyorum (Stejneger)
Brimley's Dusky Salamander

42. Head with conspicuous large pores; vomerine and parasphenoid teeth in continuous series; tail flattened and finned toward the tip; back brown; belly yellowish, usually with fine brown markings; Virginia to Georgia

Stereochilus marginatus (Hallowell) Margined Salamander

Head without conspicuous pores; vomerine and parasphenoid teeth not in continuous series 43.

43. Ends of fingers and toes very slightly expanded and indented; with slightly projecting teeth confined to the front part of the upper jaw; sides of upper jaw thin and sharp 44.

Ends of fingers rounded or tapering; teeth on upper jaw usually inconspicuous and not confined to the front 47.

44. Coloration blotched; back dark, with patches of lighter color 45.

Back dark, usually with a few small light spots or dots 46.

45. Back black, with yellow markings; W. Virginia to Ala. and Georgia

Aneides aeneus (Cope) Green Salamander

Back brown, with grayish-yellow blotching; West Coast

Aneides ferreus Cope Rusty Salamander

46. Back black, with a few light dots; tail rather stout throughout; Cal.

Aneides flavipunctatus (Strauch) Black Shasta Salamander

Back brownish, with a few small yellowish spots; tail somewhat prehensile, becoming quite slender distally; Cal.

Aneides lugubris (Hallowell) Tree Salamander

47. With 20 to 23 costal grooves, and with nine or ten costal grooves between toes of front and hind legs pressed toward each other along the sides; back dark, with light dots, with or without an obscure mid-dorsal light band; belly dark, with scattered light dots; Penna., W. Va., Ohio and Kentucky

Plethodon richmondi N. & M. Richmond Salamander

Usually with less than 20 costal grooves and with less than nine costal grooves between appressed toes, or belly light, mottled 48.

48. Belly finely and closely mottled or spotted 49.

Belly practically plain colored, except for scattered dots or large pale blotches in some species 52.

49. Costal grooves 16 to 20; eastern species 50.

Costal grooves 14 to 16; Wash. and Oregon 51.

50. Dorsal stripe, if present, usually zigzag; sides and belly mottled gray and brown; Penna. to Ind. and Ala.

Plethodon cinereus dorsalis Cope Red-backed Salamander, Gray Salamander

(*Salamandra erythronota* Green)

Dorsal stripe, if present, with straight edges; sides and belly mottled gray and white; Minn. southward and eastward

Plethodon cinereus cinereus (Green) Red-backed Salamander, Gray Salamander

(*Salamandra erythronota* Green)

51. With about four costal grooves between appressed toes; sides mottled

up to the area of the dorsal band

Plethodon dunni Bishop Dunn's Salamander

With five or six costal grooves between appressed toes; sides less mottled toward the region of the dorsal band, which may be obscured

Plethodon vehiculum (Cooper) Western Red-backed Salamander

(*Plethodon intermedius* Baird)

52. With five or more costal grooves between appressed toes; costal grooves between fore and hind limb 16 to 19 53.

With four or less costal grooves between appressed toes; costal grooves between fore and hind limb 13 to 16 55.

53. Usually with a brownish mid-dorsal band; Cal. and Oregon

Plethodon elongatus Van Denburgh California Plethodon

Back uniformly dark; eastern states 54.

54. Costal grooves 17 to 19; belly dark gray; sides with yellowish flecks; W. Virginia

Plethodon nettingi Green West Virginia Plethodon

Costal groves 16 or 17; belly light gray; sides with whitish spots and streaks; N. Y. to Ohio and W. Virginia

Plethodon wehrlei Fowler and Dunn Wehrle's Salamander

55. With a well defined yellowish or reddish mid-dorsal band or with a white stripe along each side or with two rows of red spots dorsally 56.

Not so; sometimes with frosting or blotches concentrated in a mid-dorsal band with indefinite edges 59.

56. With 13 or 14 costal grooves; dorsal band yellowish 57.

With 15 to 17 costal grooves; dorsal band reddish-brown 58.

57. Belly light colored; Washington

Plethodon vandykei Van Denburgh Van Dyke's Salamander

Belly dark colored; Idaho, Coeur d'Alene Lake

Plethodon idahoensis Slater and Slipp Idaho Plethodon

58. Belly light, somewhat blotched; back sometimes with two rows of red spots; mountains of N. C. and Virginia

Plethodon yonahlossee Dunn Yonahlossee Salamander

Belly dark, like the back; with a white stripe along each side; Ark. and Okla.

Plethodon ouachitae Dunn and Heintze Ouachita Salamander

59. With red legs or cheeks; N. C. to Tenn. 60.

No red coloring 61.

60. With red color on upper surfaces of legs; N. C.

Plethodon glutinosus shermani Stejneger Red-legged Salamander

With red cheeks; mountains of N. C. and Tenn.

Plethodon jordani Blatchley Red-cheeked Salamander

61. Throat and belly dark; back with small white spots; N. Y. and Wis. to Florida and Texas

Plethodon glutinosus glutinosus (Green) Slimy Salamander

Throat light colored 62.

62. Back mostly plain dark colored; Virginia to Georgia and Alabama
Plethodon metcalfi Brimley Metcalf's Salamander
Back frosted or blotched with lighter color 63.

63. Belly very dark; S. C.
Plethodon clemsonae Brimley Jocassee Salamander
Belly gray 64.

64. Costal grooves 14 or 15; New Mexico
Plethodon hardii Taylor New Mexico Plethodon
Costal grooves 16; mountains from Virginia to N. C.
Plethodon welleri Walker Weller's Salamander

65. With four toes on the hind foot; N. C. to Florida and Texas
Manculus quadridigitatus (Holbrook) Dwarf Four-toed Salamander
With five toes on the hind foot, one of which may be very small 66.

66. Toes well webbed; California, Sierra Nevadas
Hydromantes platycephalus (Camp) Mt. Lyell Salamander
Toes scarcely or not webbed 67.

67. Retaining gills throughout life; yellowish above, with dorsolateral light spots 68.
Adults losing gills 70.

68. With 19 or 20 costal grooves; Proctor, Oklahoma
Eurycea tynerensis Moore and Hughes Oklahoma Salamander
With 15 to 17 costal grooves 69.

69. Under side of tail pale; Bexar County, Texas
Eurycea neotenes Bishop and Wright Bexar County Salamander
Under side of tail pigmented; San Marcos, Texas
Eurycea nana Bishop San Marcos Salamander

70. Vomerine and parasphenoid teeth not in continuous series; tail half or more total length in most but not all species; usually grayish or yellowish above or with dark pigment spots in more or less well defined rows or stripes 71.
Vomerine and parasphenoid teeth in continuous series; tail usually less than half total length; general color brownish or reddish; dark pigment spots, if present, usually scattered over the body 79.

71. With 19 or 20 costal grooves 72.
Costal groves less than 18 73.

72. Grayish above; belly evenly dark; Gore, Okla.
Eurycea griseogaster Moore and Hughes Gray-bellied Eurycea
Brownish above; yellow below; Mo. to N. M.
Eurycea multiplicata (Cope) Many-grooved Salamander

73. Back orange, with scattered dark spots; W. Virginia to Alabama and Oklahoma
Eurycea lucifuga Raf. Spotted-tailed Salamander
(*Gyrinophilus maculicaudus* of Cope)
Back yellowish, with dark pigment spots in more or less well defined rows or stripes 74.

74. Pigment on body in dorsolateral line a definite stripe 75.
Pigment so situated broken up or in spots 77.

75. Dorsolateral line usually extending to the end of the tail; costal grooves 14; sides of naso-labial groove in the male forming a free projection on each side of the upper lip; Tenn. to Florida and Louisiana
Eurycea bislineata cirrigera (Green) Southern Two-lined Salamander
(*Spelerpes cirrigera* Green)
Pigment broken up or absent on half of tail toward tip; costal grooves 15 or 16; naso-labial grooves not so extended 76.

76. Sides dark-spotted below dark stripe; Virginia to Tenn. and Georgia
Eurycea bislineata wilderae Dunn Wilder's Two-lined Salamander
Sides gray-mottled below dark stripe; northeastern states
Eurycea bislineata bislineata (Green) Two-lined Salamander

77. With a black stripe down the middle of the back; Virginia to Georgia and Louisiana
Eurycea longicauda guttolineata (Holbrook) Three-lined or Striped Salamander
(*Spelerpes guttolineatus* of Cope)
Middle of back usually spotted 78.

78. With black bars on sides of tail; N. Y. to Georgia and Arkansas
Eurycea longicauda longicauda (Green) Long-tailed Salamander
Tail clouded on sides; Missouri to Texas
Eurycea longicauda melanopleura (Cope) Southern Long-tailed Salamander

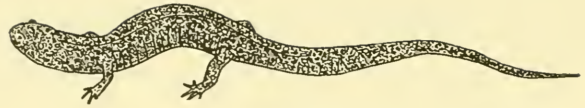
79. With a ridge marked by a light line running from eye to nostril; a dark line may or may not be present just below and parallel to this ridge 80.
No ridge or light line from eye to nostril; a dark line may or may not run from eye to nostril 82.

80. Light line from eye to nostril gray bordered below; back dark clouded or with a few scattered dark spots; northeastern states to Kentucky
Gyrinophilus porphyriticus (Green) Northern Purple Salamander (and varieties)
With a dark line from eye to nostril just below the light ridge; back and sides finely and closely dark dotted; Blue Ridge Mountain area 81.

81. Belly dark dotted
Gyrinophilus danielsi (Blatchley) Blue Ridge Purple Salamander
Belly practically clear
Gyrinophilus dunni Mittleman and Jopson Carolina Purple Salamander

82. Back brownish, with yellow flecks and clouding; Florida
Pseudotriton montanus floridanus Netting and Goin Florida Red Salamander
Back dark spotted or dotted 83.

83. Back, sides and tail dark dotted rather than dark spotted; Georgia to Louisiana

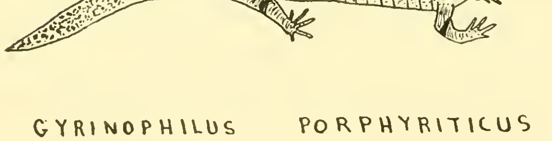


PLETHODON GLUTINOSUS

AMBYSTOMA TALPOIDEUM

A. JEFFERSONIANUM

AMBYSTOMA OPACUM



GYRINOPHILUS PORPHYRITICUS

Pseudotriton montanus flavissimus (Hallowell)
Gulf Red Salamander

Back and sides dark spotted or blotched; tail spotted or clear 84.

84\. Back with several well separated dark spots 85.
Back with many dark spots closer together 86.

85\. Back reddish-brown, much clouded with dark; N. Y. to Georgia, westward to Tenn.
Pseudotriton montanus montanus (Baird) Mountain Red Salamander, Spring "Lizard"
Back red to brownish, unclouded; Ohio to Virginia and Tenn.
Pseudotriton montanus diastictus Bishop Cave Red Salamander

86\. Back dark blotched or with irregular spots tending to fuse in old specimens; belly usually spotted 87.
Back with distinctly separate and more regular dark spots; belly usually clear 88.

87\. Legs spotted below; with light dots on snout; Georgia to Louisiana
Pseudotriton ruber vioscai Bishop Viosca's Red Salamander
Legs unspotted below; snout not light dotted; N. Y. to Georgia and Miss.
Pseudotriton ruber ruber (Sonnini) Northern Red Salamander

88\. Chin black; tail unspotted toward the tip; southern Blue Ridge Mountain area
Pseudotriton ruber schencki (Brimley) Southern Blue Ridge Red Salamander
Chin light, sometimes dark dotted; tail almost free from spots; northern Blue Ridge Mountain area
Pseudotriton ruber nitidus Dunn Northern Blue Ridge Red Salamander

89\. Back brown, marbled with darker color; costal grooves obscure; tail very thin and keeled toward the tip; Washington to Cal. and Idaho
Dicamptodon ensatus (Eschscholtz) Brown Shasta Salamander
Color not so; costal grooves more distinct; tail stouter 90.

90\. With a broad, light, mid-dorsal band; Washington to Cal., eastward to Iowa
Ambystoma macrodactylum Baird Western Long-toed Salamander
Light color, if present on back, in spots, blotches or cross bars or in dorsolateral series 91.

91\. Dorsal light color forming some bars on back or sides 92.
Dorsal light color, if present, generally distributed in spots or blotches on back or sides or concentrated in dorsolateral series 95.

92\. With whitish cross bars 93.
With yellowish cross bars 94.

93\. With 11 or 12 costal grooves on each side; with broad, white cross bars, often joined on the sides and ladder-like in appearance; N. H. to Florida and Texas, and northward in the Mississippi Valley to Illinois

Ambystoma opacum (Gravenhorst) Eastern Marbled Salamander
(*Salamandra fasciata* of De Kay)

With 13 or 14 costal grooves; with white frosting, appearing as bars on sides and often forking toward the belly; S. C. to Florida and Alabama
Ambystoma cingulatum Cope Frosted Salamander

94. With 14 or 15 costal grooves on each side; belly grayish, with white spots; Arkansas to Missouri
Ambystoma annulatum Cope Eastern Barred Salamander
(*Linguaelapsus annulatus* (Cope))

With 12 to 14 costal grooves; belly usually yellow, with dark spots, or else dark, with yellow blotches, bands or bars 102.

95. Eye as long as distance from it to end of snout; back brown, with light or dark flecks; belly orange; not over four and one-half inches long; Washington to California
Rhyacotriton olympicus (Gaige) Olympic Salamander

Eye shorter than snout; color various; size various 96.

96. Back dark spotted; sometimes retaining gills throughout life 97.

Spots, if present on back, light rather than dark 98.

97. Back well spotted with dark; dark spots on belly often lengthened crosswise; N. Dakota
Ambystoma tigrinum diaboli Dunn Devil's Lake Tiger Salamander (Axylotl (with gills))

Back less spotted with dark; belly irregularly dark spotted; Nevada to N. M.
Ambystoma tigrinum nebulosum Hallowell Clouded Tiger Salamander (Axylotl (with gills))

98. Light dorsal spots yellowish in color 99.

Light dorsal spots, if present, whitish 104.

99. Back with few yellow spots about the size of the eyes, which tend to form dorsolateral series 100.

Back or belly generally well spotted or blotched 101.

100. With two tubercles on the sole of the hind foot; yellow spots usually in dorsolateral series and also along the lower part of each side; belly grayish to yellowish; Cal.
Ambystoma tigrinum californiense Gray California Spotted Salamander
(*Ambystoma californiense* Gray)

With one or no tubercles on the sole of the hind foot; dorsal yellow spots primarily in dorsolateral series only; belly gray; Maine to Wisconsin, south to Florida and Texas
Ambystoma maculatum (Shaw) Eastern Spotted Salamander
(*Amblystoma punctatum* of Cope)

101. Usually with two tubercles on the sole of the hind foot; belly usually yellow with dark markings, sometimes marbled or barred dark and light; sometimes retaining gills throughout life 102.

With one or no tubercles on the sole of the hind foot; belly spotted or tinged with lighter color 104.

102. Back with many yellowish blotches which tend to fuse; Washington
Ambystoma tigrinum melanostictum (Baird) Northwest Tiger Salamander
(*Ambystoma tigrinum slateri* Dunn)
Yellow blotches quite distinct 103.

103. Yellow blotches few and rather large, tending to form bars to the mid-dorsal and often to the mid-ventral line; Kansas to N. M.
Ambystoma tigrinum mavortium Baird Barred Tiger Salamander (Axylotl (with gills))
With many small yellow blotches, which may form bars on the sides; generally distributed except for New England
Ambystoma tigrinum tigrinum (Green) Common Tiger Salamander (Axylotl (with gills))

104. With a raised parotoid gland on each side of the head behind the eye; dorsal edge of tail more swollen than ventral edge; back brown, sometimes sprinkled or spotted with yellow; Washington to Cal.
Ambystoma gracile (Baird) Toad Salamander
(*Ambystoma paroticum* Baird)
No noticeable parotoid glands; dorsal edge of tail usually thinner than ventral edge; color various 105.

105. With a median groove in the tongue; back usually well spotted or frosted with lighter color; costal grooves 13 to 15 106.
No median groove in the tongue; central area of back often less evidently marked with lighter color; costal grooves 10 to 14 108.

106. With light frosting on back and sides, often appearing as light bars on the sides; S. C. to Florida and Alabama
Ambystoma cingulatum Cope Frosted Salamander
With light spots or lichen-like markings 107.

107. Costal grooves 13; with one row of teeth on edge of jaw; N. and S. Carolinas
Ambystoma mabeei Bishop Mabee's Salamander
Costal grooves 14 or 15; with two or three rows of teeth on edge of jaw; Nebraska to W. Virginia, south to Georgia and Texas
Ambystoma texanum (Matthes) Narrow-mouthed Salamander

108. Tail about one-third total length; head noticeably large; costal grooves 10; southeastern states to Ill. and Okla.
Ambystoma talpoideum (Holbrook) Mole Salamander
Tail longer; head smaller; costal grooves 11 to 14 109.

109. With two tubercles on the sole of the hind foot; sometimes retaining gills throughout life; generally distributed except for New England
Ambystoma tigrinum (Green) Tiger Salamander. (Axylotl (and varieties) (with gills))
With one or no tubercles on the sole of the hind foot 110.

110. Fingers and toes long and slender, longer than the respective palms and soles; Maine to Wisconsin and Kentucky
Ambystoma jeffersonianum (Green) Jefferson Salamander, Eastern Long-toed Salamander
(*Salamandra granulata* of De Kay)

Fingers and toes shorter; northwestern Washington
Ambystoma decorticatum Cope Washington Salamander

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The names used as first choice in the salamander key are those given in the fifth edition of Stejneger and Barbour's Check List.

FROGS AND TOADS

Chapter 10

Frogs and toads belong to a division of the *Amphibia* known as *Salientia,* the "jumpers", or as *Anura,* the "tailless ones". The aptness of these terms is not apparent in the young or tadpole stage, which is characterized by a fat body, a fin-like tail and absence of limbs. As development progresses, however, limbs appear, first the posterior and then the anterior pair, and the tail is gradually absorbed. The tail is absent from the adult stages of all native frogs and toads except one northwestern species, *Ascaphus truei,* the male of which retains a short tail throughout life.

Frogs and toads are better known to most people by their songs than by sight. The calls of the various species differ decidedly from each other and are seldom heard except at the breeding season. Since one species or another is reproducing from the time the ice breaks up on the ponds until late summer, however, frog music is not rare. The performers are males, which reach the ponds first or first feel the reproductive urge and apparently attempt to attract the females by their siren songs. Strangely enough, the most penetrating cry is that of one of the smallest frogs, the spring peeper, *Hyla crucifer.* This miniature frog invades almost every puddle and, unlike most species, individuals differ considerably in the time they reproduce, so that the call may be heard from early spring until midsummer. The trill of the American toad, the low pitched "chung" of the green frog and the "jug-o-rum" of the bullfrog are familiar to most country dwellers. It is worth the effort to stalk one of these singers at night with the aid of a flashlight, as at night most animals are less easily alarmed than in daylight. The *Hylas* and *Bufos* inflate their throats into huge, balloon-like sacs as they sing. The *Ranas* are less spectacular when in action, as they have smaller sacs, and some, such as *R. pipiens,* the meadow frog, and *R. palustris,* the upland frog, have one on each side of the neck, instead of a single large one in the throat region. Frog calls are fully as hard to describe as bird songs. They have been compared to almost every sound produced by animal or machine, but most descriptions, like the phrases used in describing bird songs are of much more use in enabling one to remember the calls than in aiding the beginner to identify them. One frog, *Hyla avivoca,* owes its specific name, meaning "bird-voiced", to its call, and several have received their common names from their calls. Examples of these are the bullfrogs, peepers, cricket frogs and barking frogs. Probably more attempts have been made to describe the mating call of the spadefoot toad than any other, and comparisons include such intriguing ones as a steam calliope, the groan of a deep-voiced man having a tooth pulled, the squawk of a big rooster caught in the night, the distant honking of geese, and the cawing of young crows.

When the females have entered the ponds, a peculiar mating called *amplexus* takes place. A male grasps a female with his fore limbs, in most cases gripping her just behind her arms, and swims with her. This embrace may help to force the eggs from the body of the female. At the same time the male ejects sperm, which fertilize the eggs as they are discharged into the water. In the spadefoot toads the embrace is not axillary but inguinal, the female being grasped at the waist. A small pond full of mating frogs or toads is literally a battleground, for the males compete vigorously for their amatory privileges. Sometimes an unfortunate female is gripped by as many as three or four persistent males, so that she is submerged beneath the surface of the water by the combined weights of her admirers. Apparently the males distinguish the females by a process of trial and error, for a pursuing male will grasp a female or another male with equal readiness. A captured male's protesting croak, the slimness of his body, or some other indication warns the captor that he has made a mistake, whereupon the latter quickly relinquishes his hold to try his luck again.

The eggs make only a small mass when first laid, but the almost invisible coating of jelly around each egg quickly takes up water and swells until it is at least as thick as the width of the enclosed egg, trebling the diameter of the total. The dark colored eggs absorb heat readily and the jelly envelope or envelopes around each egg act as tiny greenhouses, trapping the heat of the sun, so that development proceeds even among fragments of floating ice. Most frogs lay their eggs in clumps. The spring peeper and the cricket frog usually scatter their eggs singly among the submerged vegetation. The true toads deposit long, curling strings of jelly containing the eggs in approximately linear arrangement.

In the northeastern states the wood frog, *Rana sylvatica,* is usually one of the first to lay. This species is peculiar in that the majority of the frogs in the pond deposit their eggs in the same spot, and, where the terrain is such that the spring thawing releases most of the frogs from their land hibernation quarters at one time, the egg-laying period lasts for only a few nights. In a large pond it is not unusual to find almost all the bunches of wood frog eggs clustered in a circle about ten feet across. Naturally, in more rugged country cut by shaded ravines, the release from under frozen debris is more gradual and the frogs are not all able to reach the pond at the same time. In that case the egg masses are less likely to be grouped in one part of the pond. Both the wood frogs and the peepers most often deposit their eggs in temporary ponds, and their tadpoles develop rapidly and transform into frogs by mid-summer, when the pond usually dries. This selection of temporary ponds frees the tadpoles from dangers from fish and some other enemies, but has its disadvantages in times of drought. Upland or pickerel frogs and meadow or leopard frogs lay a little later and in more permanent ponds. The former deposit eggs brown above and yellowish below, the latter black and white eggs, which also transform the same season. The American toad lays a bit later and prefers small ponds, often adopting garden lily ponds. Fowler's toad lays about three weeks later, and prefers more water, often utilizing quiet shallows of large lakes or streams. The males of both species may be heard trilling at intervals during the summer. The sluggards of the frog world are the green frog and the bullfrog, which do not reproduce until early summer. Both produce large floating sheets of eggs. Those of the green frog are usually among growing vegetation near shore, those of the bullfrog among brush or twigs near the center of the pond. In both cases the tadpoles pay the penalty for their parents' late appearance, the green frog spending one winter and the bullfrog two or even three winters in the tadpole stage. *Eleutherodactylus ricordii*, the robber frog of southern Florida, and probably some of the frogs of the southwest, like a number of more southern and tropical ones, lay their eggs on land, the tadpole stage being passed within the egg. These frogs lay fewer and larger eggs than the water-laying ones.

Variations and sexual differences are marked among frogs. Coloration is an unsatisfactory guide for identification. Many frogs become almost black in dull weather or in dark surroundings and light or brightly colored in sunshine. The tree frogs are extreme in this regard, rivaling the chameleon. Immature frogs are frequently spotted or marked differently from adults. The green frog has an especially bewildering range of markings in its youth. *Bufo americanus* and *Bufo fowleri* intergrade as far as markings and colors are concerned, their voices being the best distinguishing characters. Several of the other species of *Bufo* merge so that it is frequently very difficult or often impossible to tell certain specimens of one species from those of another. Many colors, especially the reds and yellows, fade or disappear entirely in preserved specimens. Sexual differences also exist. In most of the anurans the female becomes larger than the male. In some of the *Ranas* the tympanum or outer ear drum of the male is much larger than that of the female. In some frogs and toads the male has a colored or dark throat, while the throat of the female is usually white. The males of the true toads and of the spadefoot toads have a dark or black callus on each of the first two fingers. During the breeding season the males of the *Ranidae* have the thumbs greatly enlarged.

From time to time the American public is offered a "gold brick" in the form of an opportunity to invest in frog farms. Frogs' legs are an important item of diet, but so far the market has been dependent upon the natural wild supply. Unfortunately the bullfrog, the only species that attains sufficient size to be really desirable for food, takes from one to three years in the tadpole stage and from two to three more years to attain adult size in most sections of the country, so that commercial production offers many difficulties.

Frogs and toads are of far greater value as insect destroyers than as food. With the exception of the bullfrog and his near relatives, all of them do more or less hunting on land. The toads, especially, are frequent tenants of gardens and no caterpillar is too hairy or cutworm too bitter for their taste. One of the creatures in action makes a grotesque spectacle. Slowly and solemnly it walks on tiptoe around an earthworm or insect larva until it finally determines to its own satisfaction which end represents the head. Then with deliberate aim it shoots out its tongue, which is attached in front so that it may be projected to a surprising distance to adhere to its prey. The captive morsel is speedily retrieved, after which the animal sits quietly and appears to meditate for a few moments. Suddenly the eyes roll and seem to sink into the head as they help to push the food down the creature's throat. Frogs and toads, like birds, should be protected because of their economic value as insect destroyers as well as for sentimental and other less practical reasons.

The toads have been the victims of several unfortunate and erroneous superstitions. The idea that handling toads will cause warts on human hands is without foundation. The warts of the toad, however, mark the position of glands that secrete an acrid fluid when the animal is greatly alarmed or injured. A puppy, after having picked up a toad and mouthed it a bit, will drop it abruptly and show considerable distress for an hour or more. Even toad eggs contain this bitter substance, as a courageous investigator can quickly verify. Dried and powdered toads were an ancient ingredient used by apothecaries of former days. Recent studies have shown some scientific basis for this use. Another popular but false idea is that toads can live entombed in rock or sealed in corner-stones for centuries. A toad seeking hibernation quarters can work itself into small crevices, but cannot survive a summer without food or even a few days without moisture. Stories of toads buried deep in the soil have some basis. All toads bury themselves for the winter, digging deeper and deeper in order to keep below the frost line. They also bury themselves in summer to escape drought. The spadefoot toads, especially, are known to attain depths of several feet.

Frogs or toads kept as pets are best confined in a terrarium built up with moss, liverworts and other hardy woodland plants. A small dish filled with water and sunken in the vegetation provides moisture and adds greatly to the attractiveness of such a display. Small flying insects, insect larvae and earthworms appeal to most frogs. Many learn to jump for bits of raw meat dangled on the end of a string. The *Hylas* make especially interesting pets and show intriguing changes and variety of color. An educational exhibit can be maintained by raising young frogs from eggs up through the tadpole stages. The tadpoles should be removed from the original container as they hatch, so that they will not be poisoned by disintegrating egg-jelly, and placed in a balanced aquarium. After the first few days, when they begin to swim actively about in search for food, a little powdered dog biscuit or fish food may be added. Many tadpoles appreciate tiny worms or bits of raw meat. Care should be taken not to overfeed. In order to keep the water fresh, uneaten fragments should be quickly removed. As the hind limbs become well developed and the nose of each tadpole takes on a more pointed shape, the water level should be lowered and the aquarium tilted, making it possible for the tadpoles to lie with their bodies partly exposed. This is necessary because the arms have grown into the gill chambers, interfering materially with the gills, so that the action of the developing lungs must be supplemented by respiration through the skin. As soon as the fore limbs appear externally, the creatures may be removed to a terrarium. Small insects, such as fruit flies of the genus *Drosophila,* make excellent food at this time.

In general, the remarks on study methods made at the end of the salamander chapter hold also for frogs. There is much need for study of life histories under natural conditions. Much of the descriptive work has of necessity been based on collections made by some biologist during a brief trip into a new area. Such observations may lead to errors. For example, if one finds two size groups of one species he may infer that they represent the year-old and the two-year-old groups, when they might equally well be from two spawnings during one year. Some forms, such as the spadefoot toad, have been reported to spawn at three different times in one year, even in northern states. A collector visiting the ponds and finding well grown tadpoles shortly after the third spawning was reported, and unaware of the earlier spawnings, might easily be deceived into thinking that development was remarkably rapid. Continuous studies, such as those made by the Wrights on the frogs of the Ithaca region, are needed for all forms. Methods of marking individuals, by tattooing or some method not likely to handicap the animal, would make it possible to check on the rate of growth, seasonal migration, age at which sexual maturity is reached, and length of life under normal conditions.

Hibernation offers another challenge. Where and how far do the animals go in search of suitable hibernation quarters? How do they avoid freezing and how much cold can a dormant frog endure? How great is the mortality during hibernation?

Choice of breeding sites also is in need of study. How far do the animals go in search of a suitable site? Do they return to the place in which they developed? Do they return to the same place each year? Why is one pond selected in preference to another? Why do the American and Fowler's toads of the same area usually select different spawning sites? Is egg-laying correlated with certain air and water temperatures?

These are but a few of the questions upon which we need more data and which the amateur can help solve by observations in his own home territory. A good indication of the need for study on frogs is the fact that even in the southeastern states, where biologists have lived and studied for over two hundred and fifty years, two species of frogs, both of good size and one almost as large as the bullfrog, were overlooked and not even named until very recently (*Hyla avivoca* by Viosca in 1931 and *Rana heckscheri* by Wright in 1924).

The characters used in the key need little explanation.

LENGTH

This measurement is of the head and trunk, the hind legs not being included. Length of the head is taken from the tip of the snout to the rear margin of the tympanum.

HEAD

On the side of the head, behind the eye, is usually a smooth disc, the *tympanum*, tympanic membrane, or ear drum. Amphibians have no outer chamber to the ear. On top of the head in some forms are two structures useful in identification. One of these, present in the *Bufonidae* and most *Scaphiopodidae*, consists of a pair of elevated glands, the *parotoids*. They, with other glands, secrete a bitter fluid which protects the possessor from many enemies who might otherwise eat him. Some snakes devour toads in spite of this protection, however. The other head character, developed only in some of the *Bufonidae*, consists of *cranial crests* or raised folds of skin on the top of the head and sometimes extending behind the eyes. The shape of the eye pupil is a useful character in the identification of living specimens but seldom of value with preserved ones. The *Scaphiopodidae* have contractile pupils, which close vertically in the daytime like those of a cat. The *Ascaphidae*, also, have elliptically vertical pupils. The other frogs and toads have elliptically horizontal pupils.

TRUNK

The surface of the ventral side—granular in most climbing frogs and in the toads, smooth in most aquatic frogs—aids in identification. In some of the *Ranidae* preservation may bring out granules that do not appear on the living animals. The *Ranidae* are relatively smooth bellied and have no toe discs, a combination of characters that sets them apart from most other frogs. The *dorsolateral ridges*, folds of skin separating the back from the sides, vary in their degree of development. For example, in the meadow frog these folds run the full length of the trunk, in the green frog they extend about halfway back, and in the bullfrog they are not developed at all.

LEGS

The enlarged thumb on the forelimb of the male *Ranidae* is characteristic of that family. The presence or absence of discs on the ends of fingers and toes indicates climbing ability or lack of it. The *Acris* and *Pseudacris* groups have this structure much reduced, so it pays to use a hand lens in examining fingers and toes on small frogs. These toe discs are circular in the *Hylidae*, transversely oval in most of the *Leptodactylidae*. The amount of webbing is fairly well correlated with habitat. It oftens calls for close examination to determine the particular toe joint to which the web extends.

Beginners sometimes fall into error when femur or tibia is to be examined. It should be remembered that the femur is the section of the hind leg nearest the body, the tibia (or tibio-fibula) the second, and that the third segment, sometimes mistaken for the tibia, is an elongated section of the tarsus or ankle.

TADPOLES

The identification of tadpoles is rather difficult and should be undertaken by the beginner only when mature tadpoles—with hind legs but without visible fore legs—are available. At that stage the epidermal teeth around the mouth are at their best stage of development and their examination under a lens will reveal their shape and arrangement. A knowledge of the habitat and life histories of local frogs will be of considerable aid. For example, the tadpoles of wood frogs would almost always be found in temporary ponds, while tadpoles of green or bullfrogs would rarely be found except in permanent ponds. Size differences and differences in time of metamorphosis also are of much aid in the identification of tadpoles. A collection of mature tadpoles, complete with data on habitat and time of collection, would be of much value to research workers.

EGGS

Time of year, place and manner of deposition of eggs, and the number and arrangement of the jelly membranes are all useful in identification. The excellent descriptions and illustrations by the Wrights should be carefully studied. For later study, eggs are best fixed in Smith's fluid, which keeps both egg and membranes in good condition. Freshly laid eggs should be used, if possible, as the jelly layers become less distinct as the egg develops. Smith's fluid consists of

Potassium bichromate	0.5 grams
Formalin (comm.)	10.0 cc.
Water	87.0 cc.
Glacial acetic acid	2.5 cc.

The acetic acid should not be added much before the fixative is to be used, as it may cause some deterioration of the fluid during storage. The eggs should be fixed in this fluid for 24 hours, washed in running water for 6 hours, and then put in 3 or 4% formalin (not stronger) for storage. The formalin should be changed at intervals until it no longer becomes discolored.

OUTLINE OF CLASSIFICATION OF NATIVE FROGS AND TOADS

Order SALIENTIA (or *Anura*) of Class AMPHIBIA

Tail not retained by adult; pectoral and pelvic girdles specialized

Family ASCAPHIDAE (or *Discoglossidae*) Bell or Ribbed Toads

With tail-like process (male) or short anal tube (female); pupil vertical (by day); no visible tympanum; ribs present; upper jaw with teeth

One genus — *Ascaphus* (1 species)

Family SCAPHIOPODIDAE (or *Pelobatidae*) Spadefoot Toads

Pupil vertical (by day); upper jaw with teeth; parotoid glands round or indistinct; no cranial crests; with a large, horny digging process on heel

One genus — *Scaphiopus* (6 species)

Family BUFONIDAE True Toads

No teeth in jaws; parotoid glands oval or reniform; cranial crests usually present; with a small digging process on heel

One genus — *Bufo* (17 species)

Family HYLIDAE Tree Frogs

With circular discs on ends of digits; skin of belly usually granular; upper jaw with teeth; no parotoid glands or cranial crests; thumbs of males not enlarged

Three genera — *Acris* (2 species)
Pseudacris (6 species)
Hyla (12 species)

Family LEPTODACTYLIDAE Barking or Robber Frogs

Ends of digits T-shaped (with transverse discs); skin of belly usually smooth; otherwise much like the *Hylidae*

Three genera — *Leptodactylus* (1 species)
Eleutherodactylus (2 species)
Syrrhophus (2 species)

Family RANIDAE Common Frogs

Upper jaw with teeth; without toe discs or parotoid glands; toes well webbed; thumb of male enlarged at base; tympanum evident

One genus — *Rana* (17 species)

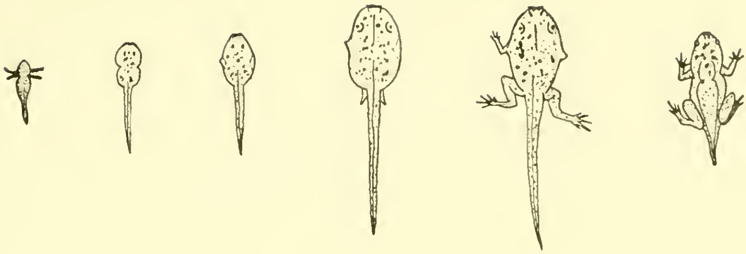
Family BREVICIPITIDAE Narrow-mouthed Frogs

No teeth in jaws; head very small; no tympanum visible

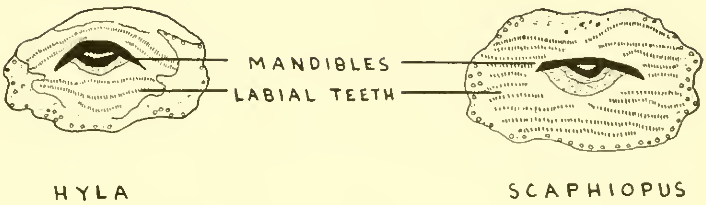
Two genera — *Gastrophryne* (3 species)
Hypopachus (1 species)

KEY TO THE PRINCIPAL GROUPS OF TADPOLES

1. Tadpole stage completed in the egg jelly
   Family *Leptodactylidae* Robber Frogs



STAGES OF TADPOLES



MOUTH PARTS (MUCH ENLARGED)

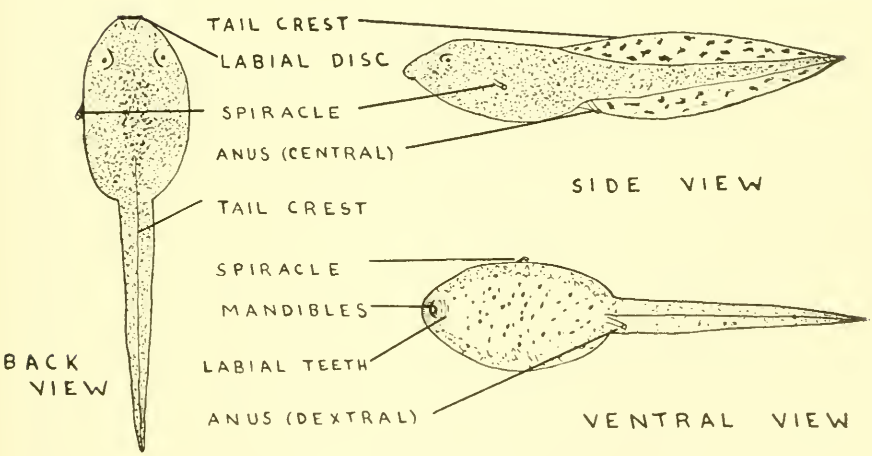


DIAGRAM OF A TADPOLE

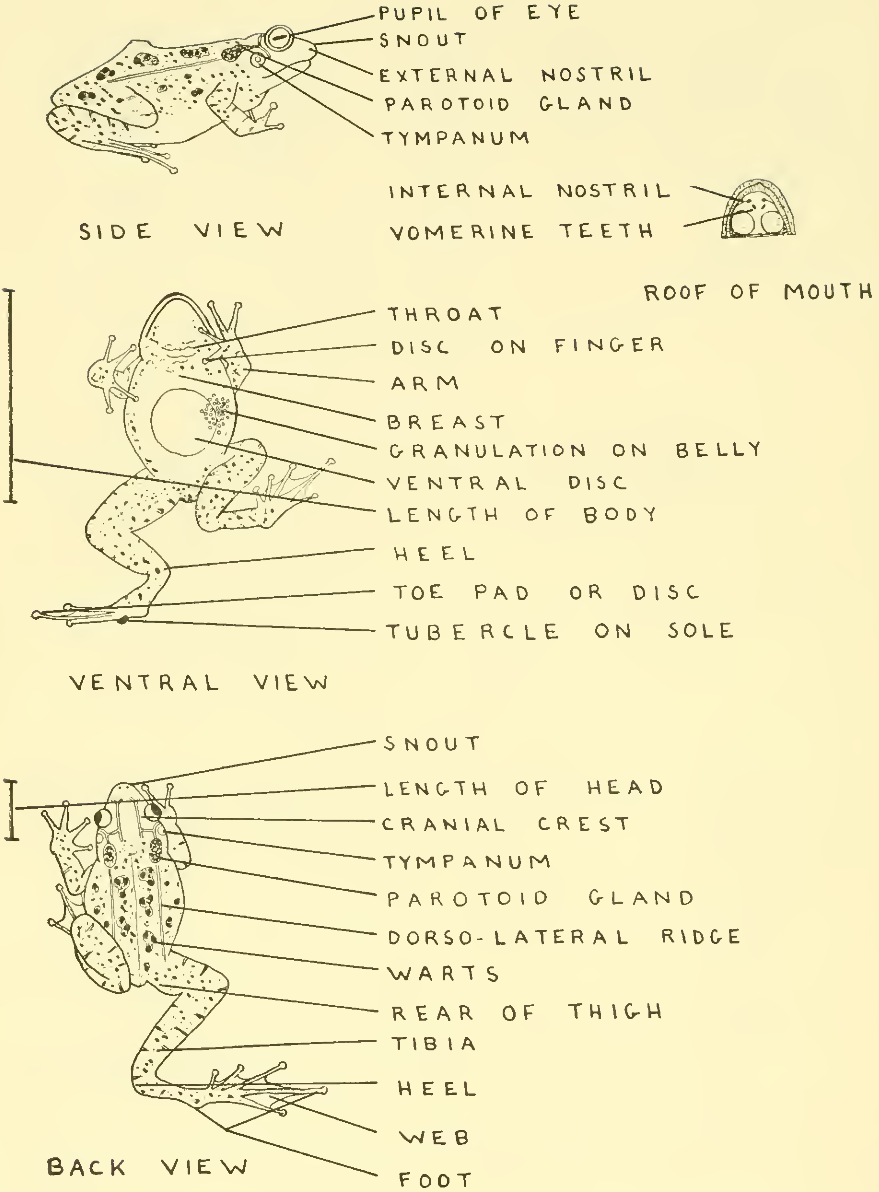


DIAGRAM OF A FROG

With a free-swimming tadpole stage 2.

2. Spiracle situated in the mid-ventral line 3.
Spiracle situated on the left side 4.

3. No labial teeth; spiracle next to the anus; usually with some white color dorsally
Family *Brevicipitidae* Narrow-mouthed Toads
With labial teeth; spiracle near the middle of the belly; body dark
Family *Ascaphidae* Bell Toad

4. Anus situated in the mid-line 5.
Anus situated slightly to the right of the base of the tail 6.

5. With three to six rows of labial teeth above (these rows may or may not be broken); with four to six rows of labial teeth below
Family *Scaphiopodidae* Spadefoot Toads
With two rows of labial teeth above; with three rows of labial teeth below
Family *Bufonidae* True Toads

6. Tail crest high and extending far forward on the body; with two rows of labial teeth above; with two or three rows of labial teeth below
Family *Hylidae* Tree Frogs
Tail crest usually not high or extending much forward on the body; with two or more rows of labial teeth above; with three or more rows of labial teeth below
Family *Ranidae* True Frogs

KEY TO THE PRINCIPAL SPECIES OF FROGS AND TOADS

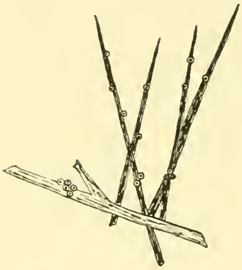
1. Head and mouth noticeably small in proportion to the body; no visible tympanum; with a fold of skin running crosswise behind the eyes; Family *Brevicipitidae* Narrow-mouthed Toads 2.
Not so 5.

2. With two large tubercles on the sole of the hind foot; Texas
Hypopachus cuneus Cope Taylor's Toad
With one small tubercle on the sole of the hind foot 3.

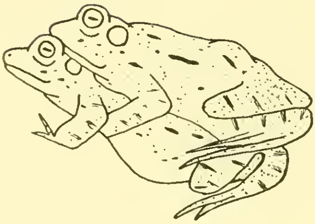
3. Belly plain; body slender, greatest width being one-half or less the length; Kansas to Texas
Gastrophryne olivacea (Hallowell) Western Narrow-mouthed Toad
Microhyla olivacea (Hallowell)
(*Gastrophryne texensis* (Girard))
Belly spotted; body stout, greatest width being more than one-half the length 4.

4. Usually with a dark stripe or band running obliquely down each side of back; skin relatively smooth; length of leg to heel equals the length of the body from the insertion of the arm backwards; Indiana to Florida and Texas
Gastrophryne carolinensis (Holbrook) Eastern Narrow-mouthed Toad
Microhyla carolinensis (Holbrook)

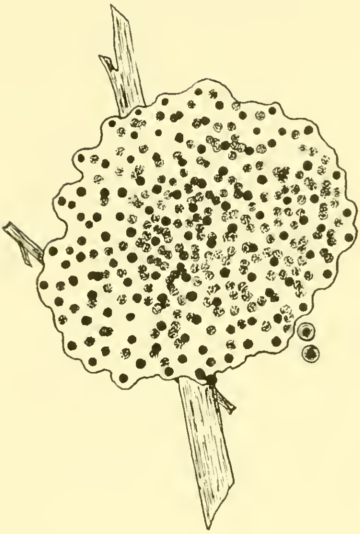
TOAD SINGING



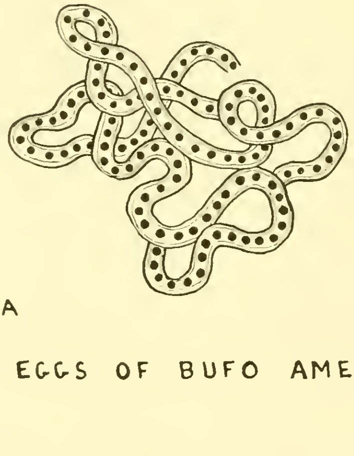
EGGS OF HYLA CRUCIFER



AMPLEXUS



EGGS OF RANA SYLVATICA



EGGS OF BUFO AMERICANUS

Back gray, marbled with darker color; skin of back pustular; legs shorter; Texas

Gastrophryne areolata (Strecker) Mitchill's Narrow-mouthed Toad

Microhyla areolata (Strecker)

5. With parotoid glands or with a large, black, cutting tubercle on the sole of the hind foot, or both; pupil of eye vertical, round or horizontal 6.

No parotoid glands; tubercles on the soles of the hind feet small or light colored; pupil never vertical 32.

6. Belly smooth or wrinkled but not definitely granulated; pupil of eye higher than wide in bright light 7.

Belly granulated; pupil of eye slightly wider than high; Family *Bufonidae* True Toads 13.

7. Inner tubercle on the sole of the hind foot small; toes only slightly webbed; male with a short tail; Washington to Montana and California, in mountain streams; Family *Ascaphidae*

Ascaphus truei Stejneger Bell Toad

Inner sole tubercle large; toes well webbed; no tail in the adult; Family *Scaphiopodidae* Spadefoot Toads 8.

8. Parotoid glands absent; skin loose over top of head; back blackish, with scattered, irregular tubercles; Subgenus *Spea* 9.

Parotoid glands present, although indistinct in *S. couchii;* skin tightly applied to top of head; back brownish to greenish, with many small, uniform tubercles; Subgenus *Scaphiopus* 11.

9. Skin almost smooth; with a bony elevation between the eyes; Texas to N. D. and Idaho

Scaphiopus bomifrons Cope Western Plains Spadefoot

Skin well sprinkled with tubercles or warts; area between the eyes smooth, lengthwise ridged, or with a glandular elevation 10.

10. Area between the eyes flat and smooth; West Coast, and southeastward to Ariz. and Texas

Scaphiopus hammondii Baird Western Spadefoot

Area between the eyes lengthwise ridged or with a glandular elevation; Great Basin, Ariz. to Idaho and Washington

Scaphiopus intermontanus (Cope) Great Basin Spadefoot

11. Parotoid gland and tympanum indistinct; back usually marbled with lighter color; Texas to N. D. and Idaho

Scaphiopus couchii Baird Couch's Spadefoot

Parotoid gland and tympanum distinct; light color on back usually as two more or less distinct lengthwise stripes 12.

12. Mid-area of top of head just behind the eyes (frontoparietal) elevated and tubercular; end of snout truncated, not extending beyond the mouth; Okla. to Ark. and Texas

Scaphiopus hurterii Strecker Hurter's Spadefoot

Frontoparietal area not noticeably elevated or tubercular; end of snout more rounded, overhanging mouth; Mass. to Florida and Texas

Scaphiopus holbrookii (Harlan) Eastern Spadefoot

13. Cranial crests present 14.
No cranial crests or with very obscure indications of them 23.

14. Lower edge of parotoid gland below the middle of the tympanum, usually level with the lower margin or below 15.
Lower edge of parotoid gland above the middle of the tympanum 17.

15. Parotoid glands enormous, triangular, about as large as the sides of the head; color usually brownish; the largest native toad, getting to be eight inches long; southern Texas
Bufo marinus (Linn.) Giant Toad
Parotoid glands smaller, oval 16.

16. With conspicuous glands on tibia and femur; cranial crests curved around behind the eyes posteriorly; color greenish; California
Bufo alvarius Girard Colorado River Toad
No such glands; cranial crests straight, inconspicuous; color grayish to brownish, usually with a light mid-dorsal stripe; the smallest native toad, getting to be one and one-quarter inches long; N. C. to Florida and Louisiana
Bufo quercicus Holbrook Oak Toad

17. With a transverse ridge joining the posterior ends of the parallel cranial crests and extending obliquely sideways scarcely behind the eyes, ending abruptly; usually with a dark band, bordered with light below, along each side; North Dakota
Bufo hemiophrys Cope Northern Toad
No transverse ridge joining the cranial crests posteriorly; color various 18.

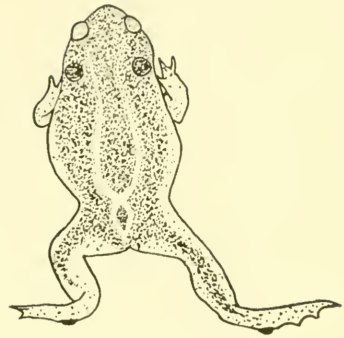
18. With widely divergent cranial crests joining anteriorly in a conspicuous boss or knobby elevation; body skin enclosing femur; Minn. to Calif.
Bufo cognatus Say Plains Toad
Cranial crests not so; body skin enclosing half or less of femur 19.

19. Cranial crests almost as far apart as the parotoid glands; parotoid glands triangular; both sole tubercles inconspicuous; with an oblique light band along each side; Louisiana to New Mexico
Bufo valliceps Wiegmann Mexican Toad
Cranial crests much nearer together; parotoid glands oval; inner sole tubercle enlarged and with a narrow cutting edge; color various 20.

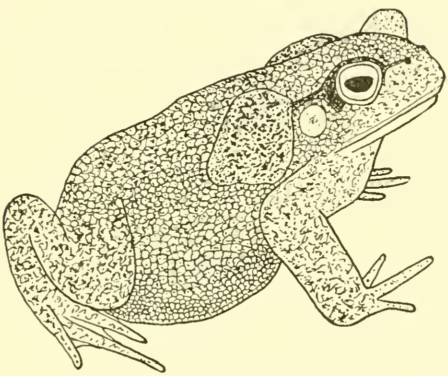
20. Cranial crests elevated posteriorly and swollen into knobs; parotoid glands short-oval; N. C. to Florida and Louisiana
Bufo terrestris (Bonnaterre) Southern Toad
(*Bufo lentiginosus lentiginosus* of Cope)
Cranial crests not so; parotoid glands long-oval 21.

21. With a short ridge or crest passing backwards from the postorbital crest (transverse ridge behind the eye) to the parotoid gland; parotoid glands usually nearer together than the length of one gland; belly often more or less spotted; eastern U. S. to Oklahoma
Bufo americanus Holbrook American Toad
No ridge or crest so situated; parotoid glands usually farther apart; ventral spots, if present, usually restricted to a small area on the breast 22.

GASTROPHRYNE CAROLINENSIS

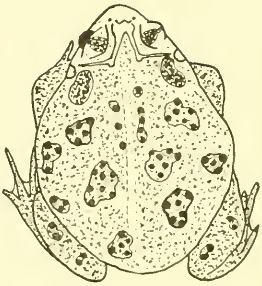


SCAPHIOPUS HOLBROOKII



BUFO MARINUS

BUFO WOODHOUSII FOWLERI



BUFO COGNATUS

22. End of nose flattened; length more than four and one-half times the length of the head (to the rear margin of the tympanum); general color brownish; warts large and usually only one or two to a color spot; adults often over four inches long; western states to Iowa

Bufo woodhousii woodhousii Girard Rocky Mountain Toad

End of nose rounded; length less than four and one-half times the length of the head; general color grayish; warts small and usually several to a color spot; adults seldom much over three inches long; Maine to Georgia, and westward to Michigan. Iowa and Texas

Bufo woodhousii fowleri Hinckley Fowler's Toad

23. Parotoid gland as large as the side of the head and descending on the side below the tympanum 24.

Parotoid gland smaller and higher 25.

24. Nostrils at tip of snout; dark color on back in a more or less reticulated pattern; Kansas to Texas and N. M.

Bufo insidior Girard Reticulated Toad

Nostrils not quite at tip of snout; back usually dark dotted; Texas

Bufo debilis Girard Little Green Toad

25. Parotoid glands almost evenly round or triangular, about the size of the eyes; Kansas to Texas and California

Bufo punctatus B. & G. Canyon Toad

Parotoid glands definitely longer or larger 26.

26. No definite, light, mid-dorsal streak; belly usually plain; no gland on tibia 27.

With a light mid-dorsal streak; belly usually spotted; an enlarged gland on the tibia 28.

27. Body skin enclosing femur; Nevada to Okla. and Texas

Bufo compactilis Wiegmann Compact Toad

Body skin about half enclosing femur; California

Bufo californicus (Camp) Southern California or Arroyo Toad

28. Space between the parotoid glands slightly less than the width of one gland; Sierra Nevadas, California

Bufo canorus Camp Yosemite Toad

Space between the parotoid glands greater than the width of one gland 29.

29. Black markings on belly about half obscuring light color; rear parts black, with light tubercles; restricted to springs in Inyo County, California

Bufo exsul Myers Black Toad

Dark markings on belly fewer and more restricted; rear parts gray 30.

30. Limbs very short; elbow and knee do not meet when pressed toward each other along the side; southern Nevada

Bufo boreas nelsoni Stejneger Nelson's Toad

Limbs longer; elbow and knee of appressed fore and hind limbs meeting or overlapping 31.

31. Belly usually well spotted with dark; nose pointed and sloping; Colorado to northern California, and northward

Bufo boreas boreas (B. & G.) Northwest Toad

Belly usually scarcely dark spotted; nose short and steep; Cal. and Nevada

Bufo boreas halophilus (B. & G.) California Toad

32. Belly granulated or pebbled; with large or small circular pads or discs on the ends of fingers and toes; Family *Hylidae* Tree Frogs 33.
Belly smooth; fingers and toes with small, transversely oval pads or without pads or discs 63.

33. Webs between the toes minute or absent; mostly under two inches long (head and body) 34.
Fourth toe of hind foot half or more webbed; size various 44.

34. Color on back in two more or less well defined stripes or rows of spots, one on each side of the mid-line, which may or may not bend toward the mid-line and join in a cross-shaped pattern 35.
With a dark stripe or row of spots down the middle of the back (sometimes obscure to absent), with or without another stripe or row of dark spots on each side 37.

35. Thighs yellow behind; back usually with a dark band on each side, these tending to bend toward the mid-line and join in a cross-shaped pattern; Ohio to Maryland
Pseudacris brachyphona (Cope) Mountain Chorus Frog
Thighs spotted with yellow behind; back usually with dark blotches or with obscure dark stripes 36.

36. Vomerine teeth between the internal nostrils; dark band through the tympanum extending back above the arm; N. C. to Florida and Louisiana
Pseudacris ornata (Holbrook) Ornate Swamp Frog
(*Chorophilus ornatus* of Cope)
Vomerine teeth behind the internal nostrils; dark band through the tympanum ending just before the arm; Texas
Pseudacris streckeri Wright & Wright Texas Chorus Frog

37. Jaw pointed; with only one dark stripe or row of dark spots (often absent) down back, (not counting the dark band on each side back through the tympanum); with a light line down the outer side of the tibia; getting to be a little over one-half an inch long; southeastern states
Pseudacris ocularis (Holbrook) Little Chorus Frog
Jaw rounded; with three dark stripes or rows of blotches down back (besides the tympanic stripes); larger; getting to be more than three-quarters of an inch long 38.

38. Usually with lengthwise dark markings on the hind legs; dark band back through the tympanum usually more conspicuous than the other markings on the back; Virginia to Georgia
Pseudacris brimleyi Brandt and Walker Brimley's Chorus Frog
Usually with transverse dark marking on the hind legs; dark band back through the tympanum not conspicuously more distinct than the other markings on the back; *P. nigrita* complex 39.

39. Legs very short; length of leg to heel scarcely extending forward to the posterior margin of the tympanum; northwestern U. S.
Pseudacris nigrita septentrionalis (Boulenger) Northwest Chorus Frog
Legs longer 40.

40. Length of leg to heel (when extended forward) equal or less than the distance from the eye backwards 41.
Length of leg to heel longer than the distance from the eye backwards 42.

41. Color on back in dark blotches; Kansas to Texas
Pseudacris nigrita clarkii (Baird) Clark's Chorus Frog
Color on back arranged as more or less well defined stripes; N. Y. to to Arizona and Idaho
Pseudacris nigrita triseriata (Wied) Striped Tree Frog

42. Color on back usually in dark lengthwise bands; back smooth; Penna. to Florida
Pseudacris feriarum (Baird) Eastern Swamp Cricket Frog
Color on back usually as rows of spots; back tubercular 43.

43. With a light line along the upper jaw; S. C. to Florida and Mississippi
Pseudacris nigrita nigrita (Le Conte) Swamp Cricket Frog
Upper jaw spotted or barred; Florida
Pseudacris nigrita verrucosa (Cope) Florida Swamp Cricket Frog

44. With inconspicuous pads on ends of fingers and toes; rear of thigh with alternating light and dark bars; back with lengthwise dark markings; adults seldom much over an inch long 45.
Pads on ends of fingers and toes more distinct; rear of thigh without alternating light and dark bars; size larger, except for *H. crucifer,* which has a dark, cross-shaped marking on the back 46.

45. Web on hind foot extending almost to the end of the longest toe; length of leg to heel (when extended forward) shorter than head and body; east of the Rockies
Acris crepitans Baird Cricket Frog
Web on hind foot shorter; length of leg to heel extending forward to beyond snout; coastal regions from Virginia to Louisiana
Acris gryllus (Le Conte) Southern Cricket Frog

46. Discs on the fingers extremely large, quite as large as the tympanum; skin of the head grown to skull; southern Florida
Hyla septentrionalis Boulenger Giant Tree Frog
Not so 47.

47. With very short webs between the fingers 48.
No webs between the fingers 56.

48. Back coarsely granulated, like the belly; Tenn. and S. C. to Florida and Louisiana
Hyla gratiosa Le Conte Barking Tree Frog
Back smooth or rough, but not with the same granulated structure as the belly 49.

49. Body extremely slender; length three times or more width through the area of the tympanum; back plain green or with a few light spots 62.
Body moderately slender; back with changeable dark markings 50.

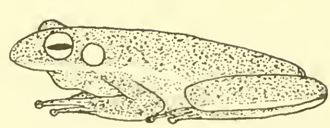
50. No dark band back through the tympanum; rear of thighs plain yellowish; Utah to Cal. and Texas
Hyla arenicolor Cope Canyon Tree Frog

HYLA CRUCIFER

PSEUDACRIS NIGRITA TRISERIATA

HYLA VERSICOLOR

ACRIS GRYLLUS



HYLA CINEREA CINEREA

With a dark band on each side of the head back through the tympanum; rear (concealed) surfaces of thighs light spotted or with dark blotches, frosting or network 51.

51. No light spot below the eye; rear of thigh usually light spotted or plain 52.

Usually with a distinct light spot below each eye; rear of thigh usually spotted or reticulated with dark, which may give the appearance of light spots on a darker background 53.

52. Rear of thigh brown, with definitely rounded yellow or orange spots; legs short; length of leg to heel scarcely reaching forward to the eye; Virginia to Florida and Texas

Hyla femoralis Latreille Pine Woods Tree Frog

Rear of thigh usually plain yellowish; legs longer; length of leg to heel reaching forward to a point before the eye; Arizona and New Mexico

Hyla wrightorum Taylor Wrights' Tree Frog
(*Hyla eximia* Baird (part))

53. Dark band through the tympanum turning downward on the shoulder; with a white ring around the insertion of the arm; southern Texas

Hyla baudinii baudinii (D. & B.) Mexican Tree Frog

Dark band through the tympanum not turning downward on the shoulder 54.

54. Thighs greenish, with a darker network; eyes protruding well beyond the line of the jaw when viewed from above or below; voice like a bird's whistle; Ill. and Tenn. to Florida and Louisiana

Hyla avivoca Viosca Bird-voiced Tree Frog

Thighs with yellow and brown reticulation; eyes scarcely protruding beyond the line of the jaw; voice a trilling croak 55.

55. Back almost smooth; rear of thigh typically with small yellow spots on a brown background; Arkansas to Texas

Hyla versicolor chrysoscelis (Cope) Cope's Tree Toad

Back usually with small warts; rear of thigh typically with a brown network on a yellow background; Maine to Minn., and southward to Florida and Texas

Hyla versicolor versicolor (Le Conte) Common Tree Toad, Rain Toad

56. With a dark band back through the area of the tympanum 57.
No such dark band 61.

57. Back green, with a white border along each side; posterior (concealed) surfaces of thighs purplish, spotted with yellow or orange; N. J. to N. C.

Hyla andersonii Baird Cedar Swamp Tree Frog

Back with dark color markings, which may vary or disappear in some specimens; rear of thighs yellowish or brownish, dark dotted or plain 58.

58. With a more or less definite cross-shaped marking on the back; rear of thighs usually dark speckled; not over one and one-half inches long 59.

Back with changeable dark spots or stripes, which may be absent; rear of thighs usually plain yellow; adults larger 60.

59. With a dark line along the margin of the upper jaw; belly almost plain; Maine to N. D., southward to Florida and Kansas

Hyla crucifer crucifer Wied Spring Peeper

(*Hyla pickeringii* of Cope)

With dark spots along the margin of the upper jaw; belly dark spotted; Georgia to Florida

Hyla crucifer bartramiana Harper Southern Peeper

60. Posterior half of edge of upper jaw dark; dark band back through the tympanum usually continuing along the side as a series of dark spots; westward from Montana and Arizona to the coast

Hyla regilla B. & G. Pacific Tree Frog

With a light line along the upper jaw back to the shoulder or beyond; dark band through the tympanum continuing back to the shoulder; Indiana to Florida and Texas

Hyla squirella Latreille Southern Oak Tree Frog

61. Frog moderately slender; length less than three times width through the area of the tympanum; back with changeable dark markings, which may be absent; rear of thighs yellowish, usually unspotted; Indiana to Florida and Texas

Hyla squirella Latreille Southern Oak Tree Frog

Frog very slender; length greater in proportion to width; back pale green or with a few light spots; rear of thighs purplish, usually unspotted 62.

62. With a distinct light band as a border between the darker color of the back and the light under surface; back yellowish-green; Florida to Virginia and Texas; northward to Illinois

Hyla cinerea cinerea (Schneider) Green Tree Frog

No distinct light border between the color of the back and the under surface; color bluish-green; Virginia

Hyla cinerea evittata (Miller) Marsh Tree Frog

63. Webs between the toes minute or absent; with or without small transverse discs on the ends of fingers and toes; Family *Leptodactylidae* Robber Frogs 64.

Toes of hind feet well webbed; no discs on ends of fingers and toes; Family *Ranidae* True Frogs 68.

64. Fingers and toes without pads or discs; with a dorsolateral and a lateral fold on each side; southern Texas

Leptodactylus labialis (Cope) White-lipped Frog

(*Leptodactylus albilabris* (Günther))

With small, transversely oval pads or discs on the ends of fingers and toes; no folds on sides 65.

65. Legs short; length of leg to heel, when extended forward, equal to the distance from the tympanum backwards; with reddish dorsolateral lines and snout; Florida

Eleutherodactylus ricordii (D. & B.) Florida Robber Frog

(*Eleutherodactylus planirostris* (Cope))

Legs longer; length of leg to heel reaching forward to the eye or anterior to it; color not so; Texas 66.

66. With a ventral disc; tympanum a little higher than wide; thighs not spotted behind; voice like a bark
Eleutherodactylus latrans (Cope) Texas Cliff Frog
(*Lithodytes latrans* Cope)
No ventral disc; tympanum round; thighs spotted behind; voice like a cricket's song 67.

67. Diameter of the tympanum about half or less the diameter of the eye
Syrrhophus marnockii Cope Marnock's Frog
Diameter of the tympanum more than half the diameter of the eye
Syrrhophus campi Stejneger Camp's Frog

68. Dorsolateral ridges broken or absent or extending only half way back 69.
With an unbroken dorsolateral ridge extending the length of each side of back 75.

69. Tympanum inconspicuous, about half the size of the eye, or covered with small tubercles; throat coloring not different in the two sexes 75.
Tympanum smooth, usually quite conspicuous, that of the female being about the size of the eye, that of the male larger; throat of the male usually yellow, or gray tinged with green, and usually of a different or deeper color than that of the female 70.

70. First finger distinctly longer than the second; belly usually mostly dark; throat of male usually gray, tinged with green; S. C. to Florida and Miss.
Rana heckscheri Wright River-swamp Frog
First finger about equal to or shorter than the second; belly usually mostly light colored; throat of male usually yellow 71.

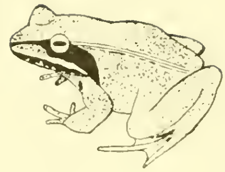
71. With two joints of fourth toe free of web; dorsolateral folds absent or extending about half way back 72.
With one or no joint of fourth toe free of web; dorsolateral folds absent or interrupted 73.

72. Dorsolateral folds extending about half way back; with much green about the head; west to Texas; introduced into Washington
Rana clamitans Latreille Green Frog, Spring Frog
Dorsolateral folds absent; usually with dorsolateral light stripes; N. J. to Georgia
Rana virgatipes Cope Striped Sphagnum Frog, Carpenter Frog

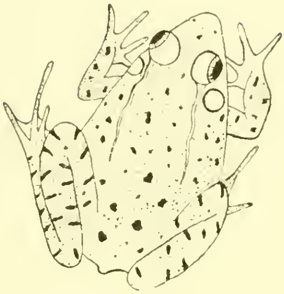
73. Body narrow; length of head and body more than two and one-half times width; fourth toe fully webbed; Georgia to Florida and Louisiana
Rana grylio Stejneger Southern or Lake Bullfrog
Body stout; length less than two and one-half times width; with one joint of fourth toe free of web 74.

74. Belly light yellow, unspotted; head narrow; length of head and body more than three times the width of the head; northern states from Maine to Minn.
Rana septentrionalis Baird Mink Frog
Belly silvery, faintly mottled with brown; head broad; length of head and body less than three times the width of the head; our largest frog, get-

ELEUTHERODACTYLUS LATRANS

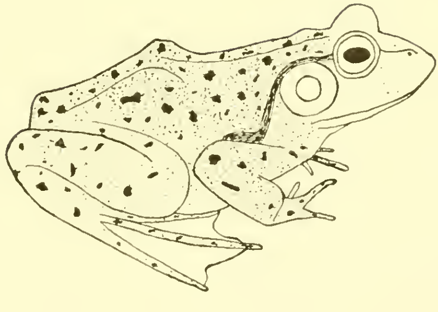


RANA SYLVATICA SYLVATICA



RANA CLAMITANS

RANA PIPIENS



RANA CATESBEIANA

ting to be eight inches long (head and body); east of the Rockies, and introduced on the West Coast

Rana catesbeiana Shaw   Common Bullfrog, Jumbo Frog

75. Either with a dark patch from the cheek back through the tympanum, or with the under parts red, or both — 76.

No dark cheek patch; under parts white or yellow posteriorly (Sometimes the under parts are red as the result of a diseased condition. Frogs having the under parts naturally red are found in the United States only in the Rocky Mountain region and westward.) — 81.

76. Under parts white or greenish; with a dark cheek patch; northern and eastern species — 77.

Under parts red or yellow posteriorly; dark cheek patch present or absent; western species — 78.

77. Back almost uniformly colored; breast scarcely spotted; Maine to S. C. and Arkansas

Rana sylvatica sylvatica (Le Conte)   Eastern Wood Frog

Back with a wide, dark, mid-dorsal band and often with a fine, light, mid-dorsal stripe; breast well spotted; Michigan north and west

Rana sylvatica cantabrigensis Baird   Northern Wood Frog

78. Length of leg to heel reaching forward to the eye; cheek patch indistinct to absent; dorsolateral ridges often absent — 87.

Length of leg to heel reaching forward to the nostril; cheek patch usually more distinct; dorsolateral ridges usually present — 79.

79. Under parts yellow posteriorly; Wash. and Idaho

Rana aurora cascadae Slater   Cascade Frog

Under parts red posteriorly — 80.

80. Skin of back smooth; West Coast, south to northern California

Rana aurora aurora (B. & G.)   Oregon Red-legged Frog

(*Rana agilis* of Cope)

Skin of back rough or tubercular; California; introduced into Nevada

Rana aurora draytonii (B. & G.)   California Red-legged Frog

81. Back with lengthwise ridges between the dorsolateral ridges; usually with a light line along the upper jaw; back usually with the dark spots about the size of the eyes in two or three rows between the dorsolateral ridges — 82.

Back smooth between the dorsolateral ridges, or with the dorsolateral ridges obscure to absent; color various — 84.

82. Dark spots on back between dorsolateral ridges squarish and closely spaced in two lengthwise rows; color brownish; under parts bright yellow posteriorly; west to Oklahoma

Rana palustris Le Conte   Upland or Pickerel Frog

Dark spots on back usually more rounded and about as far apart as one average sized spot; general color usually greenish; under part usually paler — 83.

83. Snout acute; length (head and body) about two and one-half times the length of the head to the posterior margin of the tympanum; typically with a distinct, rounded, white spot in the center of the tympanum; southeastern states to Texas

Rana pipiens sphenocephala (Cope)   Southern Leopard Frog

Snout less acute; length about three times the length of the head; if a white marking is present on the tympanum, this is typically a blotch and not a definitely rounded spot; widely distributed (For a discussion of the *R. pipiens* complex, see Wrights' HANDBOOK, page 498.)

Rana pipiens pipiens Schreber Meadow or Leopard Frog, Grass Frog

(*Rana virescens* of Cope)

84. Web on hind foot very broad, extending to the ends of the toes except the fourth, which may have one joint free; dorsolateral folds often obscure or absent 85.

Web more moderate, extending not farther than the second joint of the fourth toe (excepting a very narrow line of web parallel with the sides of the toe, which may extend slightly farther); dorsolateral folds entire 90.

85. Under parts white, except for dark clouding on the throat and a touch of yellow on the hind feet; Arizona and N. M.

Rana tarahumarae Boulenger Mexican Frog

Under parts yellow or red posteriorly; throat or breast often spotted or mottled 86.

86. Length of leg to heel extending forward to the eye; tympanum smooth; usually with a light line along the upper jaw, with or without dark mottling; under parts orange to red posteriorly 87.

Length of leg to heel extending forward about to the nostril; tympanum often with small tubercles; upper jaw usually conspicuously mottled; under parts yellow posteriorly 88.

87. Spots on the back about the size of the eyes; upper jaw practically plain, except for the light line; with two tubercles on the sole of the hind foot; Montana to Arizona, and westward

Rana pretiosa pretiosa B. & G. Western Red-legged Frog

(*Rana temporaria pretiosa* of Cope)

Spots on back usually smaller and more numerous; upper jaw much spotted and mottled, and with a light line; with one tubercle on the sole of the hind foot; Nevada into Oregon and Idaho

Rana pretiosa luteiventris Thompson Nevada Red-legged Frog

88. With a light spot on top of the head; Oregon and Cal.

Rana boylii boylii Baird Western Yellow-legged Frog

Not so 89.

89. Tympanum with many small tubercles; Cal.

Rana boylii mucosa Camp California Yellow-legged Frog

Tympanum scarcely tubercular; Cal. and Nevada

Rana boylii sierrae Camp Sierra Yellow-legged Frog

90. Upper jaw almost uniformly colored; skin of back smooth; Nevada

Rana fisheri Stejneger Nevada Spotted Frog

(*Rana onca* Cope)

Upper jaw conspicuously spotted or mottled with dark; skin of back usually somewhat tubercular 91.

91. With many small dark spots on the throat region; dark spots on back (about size of eye) irregular in shape and scarcely light bordered 92.

Central throat region unspotted; dark spots on back regularly light bordered 93.

92. Skin of back scarcely tubercular; dark spots of back distinct against a light background; N. C. to Florida
Rana capito Le Conte Pale Southern Gopher Frog
(*Rana aesopus* (Cope))
Skin of back very tubercular; dark spots of back obscure against a dark background; Ala. to Louisiana
Rana sevosa G. & N. Dusky Southern Gopher Frog

93. Skin of back scarcely tubercular; Ark. to Okla. and Texas
Rana areolata areolata B. & G. Texas Gopher or Crayfish Frog
Skin of back very tubercular; Ohio to Miss. and Okla.
Rana areolata circulosa R. & D. Northern Gopher or Crayfish Frog

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The names used as first choice in the frog and toad key are those given in the fifth edition of Stejneger and Barbour's Check List.

LIZARDS

Chapter 11

In folk-lore and mythology dragons play an important part. It is an interesting conjecture that prehistoric man may have seen giant lizards and handed down the story. Although the dinosaurs, which belong to a different subclass of reptiles from the lizards, had probably all perished several million years before man arrived, very large lizards may have still survived. To dragons were attached most of the wild-animal horror tales of imaginative travelers. The dragons of many of these stories were not extremely big, however, as the hero could and often did slice off the head of a dragon with one blow. In Raphael Sanzio's famous painting of *St. George and the Dragon,* the latter is pictured as about ten feet long. Lizards as long as this still survive in the Dutch East Indies. The Douglas Burden Expedition, collecting for the American Museum of Natural History, captured several of these dragon-lizards, *Varanus komodoensis,* and recorded that one damaged a horse so severely that the injured animal had to be shot, and another lizard swallowed the whole hind quarters of a deer. Fortunately for the beautiful maidens in distress, most of the "dragons" of today are small, and the great majority of North American species are less than a foot long. Alligators, anatomically different from lizards and belonging to a different order of reptiles, attain considerably greater size, and individuals of fifteen feet in length were fairly numerous in Florida before unrestricted hunting greatly thinned their ranks.

In many parts of the country where lizards are scarce or rare, the term "lizard" is applied to the local salamanders. The latter are readily distinguished from lizards by their complete lack of scales and by their moist skins which confine them to damp habitats. A very few of the native lizards apparently lack scales, but have external ear openings not possessed by salamanders. Some of the legless lizards, such as the glass snake, are often confused with snakes, but may be identified as lizards by the presence of more than two scales or plates before the anal opening.

Lizards, more than most reptiles, are adapted for living in a warm climate. Therefore, most of the native species are found in the southern states. When kept as pets, they lose all ambition and usually refuse to eat after summer temperatures no longer prevail. In keeping with their love of sunshine many lizards have become desert dwellers, burrowing into the sand for warmth as soon as the sun begins to sink. If the midday heat becomes excessive, however, they then also retreat to their sand burrows. As with snakes, recent studies have shown that even the desert-dwelling forms cannot survive long exposures to noonday heat and sunshine, but do make frequent excursions from one shady spot to another. The casual observer may easily mistake a temporary stop in bright sunlight for the commonly described but apparently rare "basking in hot sun". Many of them enjoy exposure to mild sunshine, and most of them have fairly high optimum temperatures. The Crocodilians share this preference for high temperatures. A growth of about a foot a year has been recorded for captive alligators kept at the optimum temperature of about 80° Fahrenheit.

Although lizards are generally feared by people unacquainted with their habits, only one species, the Gila monster, is poisonous. This animal, which gets to be about two feet long, is found in southwestern United States and Mexico. It is usually vicious and untrustworthy, when first captured. Since its poison glands are in its lower jaw, so that the poison cannot be efficiently ejected unless the animal turns upon its back, and since its poison-conducting teeth are grooved, instead of hollow needles as in most of our poisonous snakes, its bite is not always attended with serious consequences to humans. Its poison is said to be as powerful as that of the rattlesnake, however, and no chances should be taken. Unlike the poisonous snakes, the Gila monster retains its hold with great tenacity, so that it is almost impossible to shake it off.

Most lizards feed on insects. A few devour other lizards. The Gila monster, in captivity, takes readily to hens' eggs and at liberty would probably devour any available birds' eggs. The chuckawalla is herbivorous and is used by the Indians for food. Many lizards have thick, fleshy tongues and capture their prey by sudden rushes. The horned "toads" resemble toads in eating habits as well as in appearance, for they have extensible tongues, which can be projected to adhere to insects and retrieve them. The striped lizards have narrow, forked tongues much like those of snakes.

Most of the lizards are oviparous. Many bury their eggs, often in warm, damp sand, and pay them no further attention. Some species deposit eggs in rotting logs, damp moss and similar places and remain with them to help incubate or protect them. The glass snake is one of the lizards that broods its eggs. It is possible that the brooding habit is more general among lizards than has previously been supposed. A few lizards, such as the horned toads, produce living young, retaining their eggs within the body until time for hatching. The alligator lays eggs about the size and shape of goose eggs in a piled-up mass of decaying vegetation in a swamp or similar habitat. It is reported to watch over its eggs and to open up the nest when they hatch. It seems probable that it guards its young for some time thereafter.

Color variations often puzzle the collector and taxonomist and may be correlated with emotional state, sex and age. The American chameleon, *Anolis*, popularized by circus hawkers, turns from a dull brown to a vivid green when excited and often when sleeping. Environment affects its color only indirectly, for there is little attempt to match body color with surroundings. The true chameleon, a native of Africa, is a creature of far different build and greater range of color change. Sexual differences in color are often marked among lizards. *Anolis* males, when excited, often distend a throat fold so that bright red skin shows between the scales. A local name of "blood-swallowers" is based on this habit. In most of the swifts the males have patches of bright blue on the sides of the abdomen and sometimes on the throat, which color markings are often absent from the females. Age differences in lizards are also noticeable. The striped lizards, *Teiidae,* may lose their stripes and develop spots or cross bars as they age. Some species of five-lined skink have yellow stripes and bright blue tails in youth. In maturity they take on a more uniform brown. The adult males of some species develop bright red about their heads.

An odd physical peculiarity of many lizards is familiar and annoying to the collector. It consists of the ability to break off the tail, which continues to writhe and twitch for some time, while the rest of the animal slips quietly away to regenerate its lost parts. The muscles contract so that there is practically no bleeding and apparently no pain. The extreme development of this caudal autotomy is reached in the so-called glass snake, which, when roughly handled, casts off one section after another, until it has lost practically all of its tail, well over half the total length. Needless to say, the popular superstition that the animal returns and reconnects the cast-off sections has no foundation in fact. Lizards, like snakes, shed their skins, but, unlike snakes, usually in patches or small pieces, rather than as complete skins.

The alligator is unique among North American reptiles in possessing definite vocal powers. The mating song of the male alligator is a loud bellowing that sounds much like the lowing of a bull and may be heard for about a mile. Voice sacs, one on each side of the throat region, are inflated as he calls. The other native reptiles are limited to grunts and hisses, a surprising contrast to the vocal endowments of their lower relatives, the frogs.

Since lizards are frequently kept as pets, or attempts are made to keep them, a few pointers may be useful. None of them live on sweetened water, as is often stated. They will usually eat insects, such as the beetle larvae called meal worms. All of them, even desert forms, need water, which should be sprinkled around in the cage, where they can lick it up like dew. Most of them will take water greedily in this way, but seem unable to learn to drink from a dish. Warm water for bathing should also be available. They must be kept warm. If once chilled, they often stop eating and soon die. Sand, shade and sunshine should be freely available. Baby alligators, like lizards, must be kept in an even, warm atmosphere. They prefer to take their food under water and will usually eat raw, lean meat, fish or frogs. Experiments indicate that small amounts of cod or halibut liver oil may help to take the place of native sunshine in keeping pet lizards in good condition .

Identification.

The illustration showing the arrangement and names of the scales, especially those on the head, should be studied carefully. Since the names and positions of several of the head scales are the same as those of the snakes and correspond to the bones of the mammal skull, this is not a very difficult task. Some lizards have bead-like scales on the body, others have smooth but polished ones, and others have rough scales with projecting rear edges. Some forms have large scales above and small ones on the belly, while others reverse the arrangement.

Pattern is somewhat variable and depends partly upon age. Colors also vary, frequently with the emotional condition of the animal, and usually fade very badly in preserved specimens, which are commonly as disappointing as a collection of preserved fish. Many museums find colored casts much more useful for educational purposes than the best preserved or mounted originals.

Measurement of total length needs no explanation. However, the loss of part of the tail frequently detracts from the usefulness of this character. The length of the head is the straight distance from the tip of the snout to the rear of the ear opening or of the tympanum, that of the tail from anus to tip.

General habits.

The studies now in progress on optimum and maximum temperatures for different reptiles are yielding rather surprising results, and should be checked in various localities. Food preferences also need study. Some lizards are recorded as insectivorous, some as carnivorous, and some as herbivorous. These records may be correct, but observations on free animals and those on caged animals often show great differences. A captive animal may have little choice except to eat the food offered it or to starve. Since birds have enjoyed legal protection, we have developed more humane methods of bird study, and it is well to remember that field glasses and Indian-type stalking may be used on other animals besides birds. Banding could doubtless be adapted to lizards, to learn their individual ranges and life spans. Other problems will soon suggest themselves. For example, one might check the often repeated statement that scalation on a regenerating tail, if different from the original pattern, resembles that of a more primitive group of lizards. Voice is also of interest. Some writers state that the geckos are the only lizards with any vocal powers beyond a hiss or grunt. Barking lizards are mentioned in travelers' stories. Do other lizards "bark", or are the voices those of small rodents which may share the burrow or retreat?

Breeding habits.

Courtship and mating habits of lizards are not well known. It is thought that in the Amphibia these habits offer indications as to the relationship of species, and this presumably may also be true for lizards. Time and place selected for egg-laying, length and temperature of incubation period, any brooding of the eggs, and any indications of parental care should be recorded. The old natural history books often show pictures of a lizard and her family, but these were probably made from captive specimens where parent and offspring had no choice but to stay together.

OUTLINE OF CLASSIFICATION OF NATIVE LIZARDS AND CROCODILIANS

Order LORICATA (or *Crocodilia*) (of Class REPTILIA)

With two temporal openings on each side of skull, one above and one below the squamosal-postorbital bar; ribs with uncinate processes; epipubic bones present

Family CROCODYLIDAE Crocodilians

Back covered with rows of bony plates; teeth peg-like, set in sockets; bony palate extending to back of throat; quadrate bone rigidly attached to skull

Two genera — *Crocodylus* (1 species)
Alligator (1 species)

Order SQUAMATA (of Class REPTILIA)

With one temporal opening on each side, between parietal and the squamosal-postorbital bar; with one occipital condyle; no uncinate processes on ribs; no epipubic bones

Suborder SAURIA Lizards

Brain case not completely ossified in front; four limbs usually present

Family GEKKONIDAE Geckos

Pupil vertical; eye covered by rigid, transparent eyelid; scales minute; tail short and thick; digits usually widened into discs

Two genera — *Phyllodactylus* (1 species)
Coleonyx (2 species)

Family IGUANIDAE

Head and body scales all small; teeth fused to inner edge of jaw; tongue thick, not protractile

Thirteen genera — *Anolis* (2 species)
Ctenosaura (1 species)
Dipsosaurus (1 species)
Crotaphytus (4 species)

Sauromalus (1 species)
Callisaurus (2 species)
Uma (3 species)
Holbrookia (6 species)
Sceloporus (17 species)
Uta (1 species)
Urosaurus (2 species)
Streptosaurus (1 species)
Phrynosoma (9 species)

Family ANGUIDAE Plated Lizards

Scales large and smooth, squarish; with a fold of skin lengthwise along each side; tongue long and deeply forked, protractile; legs small or absent

Two genera — *Ophisaurus* (1 species)
Gerrhonotus (5 species)

Family ANNIELLIDAE

Legless; eye a narrow slit

One genus — *Anniella* (1 species)

Family HELODERMATIDAE

Scales bead-like; tail short and thick; teeth hooked; lower jaw with grooved poison fangs

One genus — *Heloderma* (1 species)

Family XANTUSIIDAE

Pupil vertical; back and sides with granular scales; abdomen with plates

One genus — *Xantusia* (4 species)

Family TEIIDAE

Tongue long, narrow and deeply forked, protractile; scales granular above

One genus — *Cnemidophorus* (7 species)

Family SCINCIDAE Skinks

Scales large and smooth, rounded; no folds of skin on sides; legs small

Three genera — *Leiolopisma* (1 species)
Eumeces (16 species)
Neoseps (1 species)

Family AMPHISBAENIDAE

No visible eyes or ears; limbs absent or vestigial; scales not overlapping, arranged in rings around the body

One genus — *Rhineura* (1 species)

(Genus *Bipes* is found in Lower California)

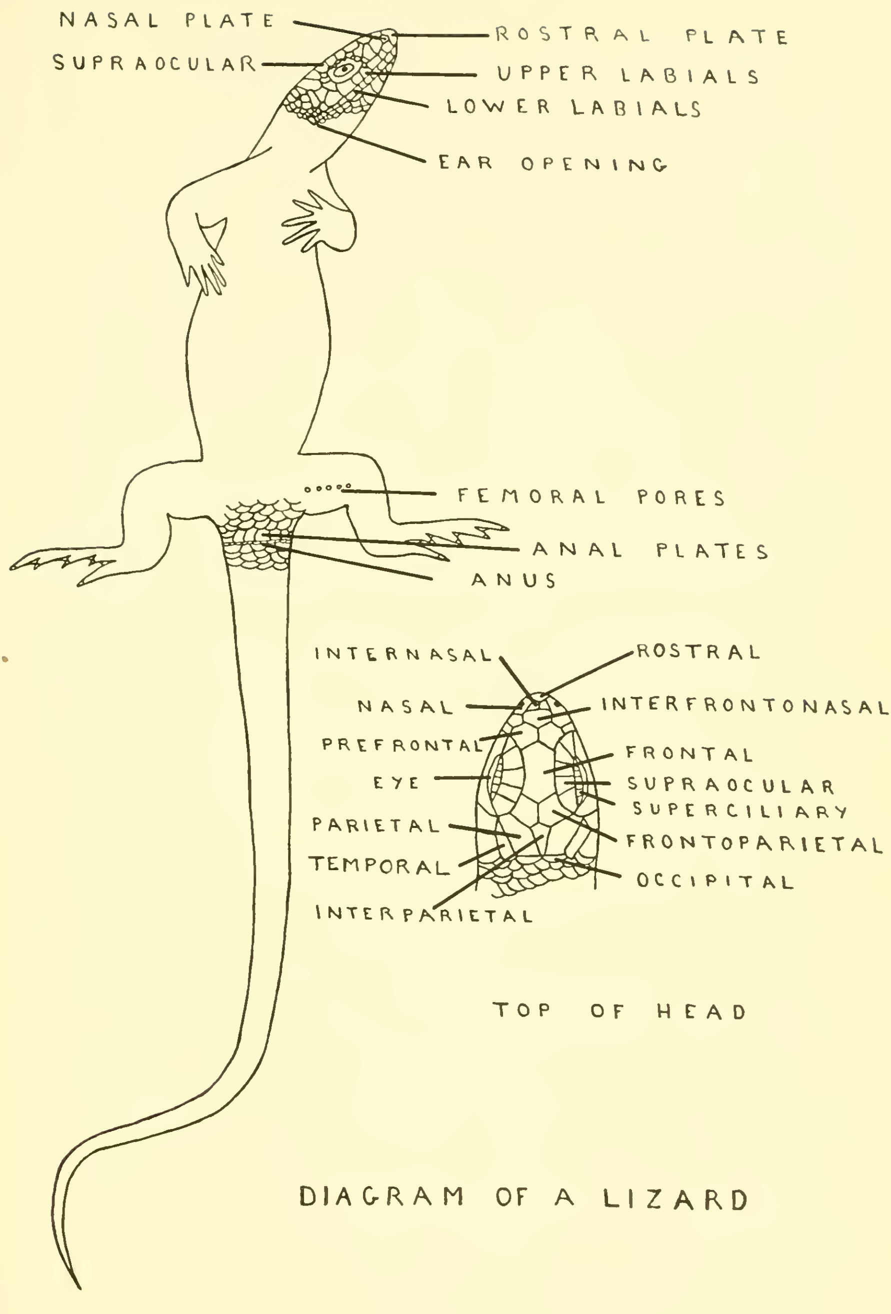


DIAGRAM OF A LIZARD

KEY TO THE PRINCIPAL SPECIES OF LIZARDS AND CROCODILIANS

1. Without legs 2.
   With legs 5.

2. No external ear openings or eyes; body apparently scaleless, with ring-like creases like an earthworm; Florida; Family *Amphisbaenidae* (part)
   Rhineura floridana (Baird) Florida Worm Lizard
   Either with external ear openings, eyes or visible scales 3.

3. With ear openings; eyes with movable lids; tail longer than body (when complete); Virginia to Wisconsin, southward to Florida and N. M.
   Ophisaurus ventralis (Linn.) Glass Snake
   (of Family *Anguidae*)
   Without ear openings; eyes covered with thin skin; tail shorter than body; California; Family *Anniellidae* 4.

4. Back silvery or buff
   Anniella pulchra pulchra Gray Silver California Worm Lizard
   Back dark brown
   Anniella pulchra nigra Fischer Black California Worm Lizard

5. With but one pair of legs, placed anteriorly; restricted to Lower California; Family *Amphisbaenidae* (part)
   Bipes biporus (Cope) Two-legged Lizard
   With two pairs of legs 6.

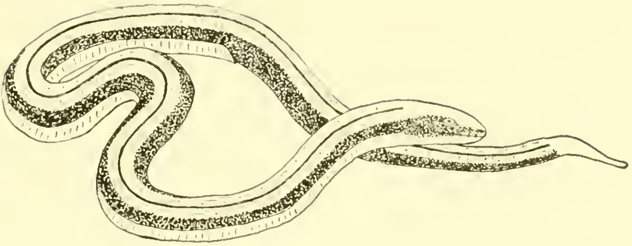
6. Anus running lengthwise; Family *Crocodylidae* (of Order Loricata) Crocodilians 7.
   Anus running crosswise 8.

7. Snout very narrow and pointed; Florida; almost exterminated
   Crocodylus acutus Cuvier Crocodile
   (*Crocodilus americanus* (Laurenti))
   Snout wider and rounded; N. C. to Florida and Texas
   Alligator mississipiensis (Daudin) Alligator

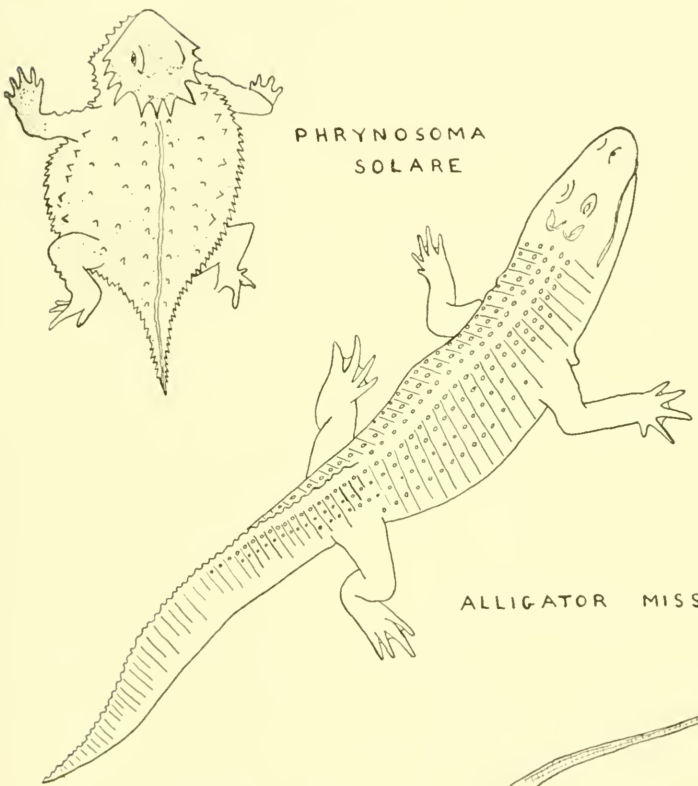
8. Body very fat, toad-like; head with spines or knobby tubercles; Family *Iguanidae* (part) Horned Lizards (Frogs, Toads) 9.
   Body more slender, lizard-like; head without spines or tubercles (the neck may or may not be spiny) 17.

9. Sides relatively smooth; tympanum or ear membrane covered with scales; Ariz. to Texas
   Phrynosoma modestum Girard Little Horned Lizard
   (*Anota modesta* of Cope)
   With one or two rows of enlarged scales along each side; tympanum hidden or variously exposed 10.

10. Head spines obsolete; scales of belly well keeled; S. Ariz.
    Phrynosoma ditmarsi Stejneger Ditmars' Horned Lizard
    Head spines present; scales of belly variously keeled to smooth 11.

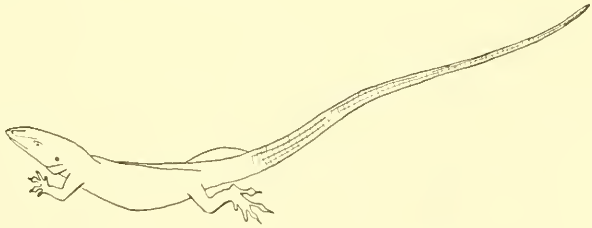


OPHISAURUS VENTRALIS



PHRYNOSOMA SOLARE

ALLIGATOR MISSISSIPIENSIS



ANOLIS CAROLINENSIS

11. With four large spines at the back of the head (occipital region) forming a continuous series with the three large temporal spines on each side

Phrynosoma solare Gray Regal Horned Lizard
(*Phrynosoma regale* (Girard))

With two occipital spines at the back of the head between the temporal spines 12.

12. Chin with three or four rows of enlarged scales on each side (of mid-line, within the row of spines on the angle of the lower jaw) 13.
Chin evenly scaled or with one row of enlarged scales so situated 14.

13. Scales on top of the head between the eyes smooth; S. Cal.

Phrynosoma blainvillii blainvillii (Gray) San Diego Horned Lizard
(*Phrynosoma coronatum blainvillii* (Gray))

Scales on top of the head between the eyes rough or striated; Cal.

Phrynosoma blainvillii frontale (Van Denburgh) California Horned Lizard
(*Phrynosoma coronatum frontale* (Van Denburgh))

14. With two rows of enlarged scales or spines along each side; head spines rather long 15.
With one row of spines along each side; head spines moderate to short 16.

15. Tympanum exposed; with a light mid-dorsal line; Colo. to Ark. and Ariz., and southwards into Mexico

Phrynosoma cornutum (Harlan) Texas Horned Lizard

Tympanum covered by scales; with a dark mid-dorsal line; Ariz. and Cal.

Phrynosoma m'callii (Hallowell) MacCall's Horned Lizard

16. With a single large temporal spine on each side of and evenly spaced with the two occipital spines (in the middle of the back of the head); chin shields (on angle of lower jaw) conspicuous and larger posteriorly; Wash. and Idaho to Ariz. and Cal.

Phrynosoma platyrhinos platyrhinos Girard Smooth Horned Lizard

With three short temporal spines grouped on each side of the two occipital spines, which are short and stubby and widely separate; chin shields mostly uniformly small; Wash. to Cal. and Texas

Phrynosoma orbiculare Wiegmann Douglass's Horned Lizard
(*Phrynosoma douglassii* (Bell))
(Several intergrading subspecies)

17. Ear opening hidden; limbs very small; with one digit on each fore limb and two on each hind limb; Florida

Neoseps reynoldsi Stejneger Two-toed Lizard
(of Family *Scincidae*)

Not so 18.

18. With a large fold of skin, lengthwise along each side, closely folded to the body; back with large squarish scales; Family *Anguidae* Plated Lizards 19.

No definite, lengthwise fold of skin along each side; back with rounded or pointed scales 28.

19. With four large scales (and several smaller ones) in a square arrangement on top of the head in front of a line drawn between the front corners of the eyes; Mexican Border
Gerrhonotus imbricatus levicollis (Stejneger) Plated Lizard
(*Barissia levicollis* Stejneger)

With three large plates in a triangular arrangement on top of the head before the eyes 20.

20. With a small median plate behind the rostral plate; belly obscurely mottled; Texas
Gerrhonotus infernalis Baird Brown Alligator Lizard

With two small plates behind the rostral plate; belly often lengthwise lined 21.

21. Scales almost smooth above, quite so on the sides; dark cross bands on back finely bordered by darker color; Ariz. and N. M.
Gerrhonotus kingii Gray King's Alligator Lizard
(*Gerrhonotus nobilis* (B. & G.))

Scales weakly to strongly keeled; back and sides with spots or with dark cross bands which may be finely light bordered posteriorly 22.

22. Usually with dark cross bars across back and sides; eye yellow; usually with fourteen lengthwise dorsal scale rows 23.

Central area of back often blotched, but seldom with dark cross bars; eye dark; with fourteen to sixteen lengthwise dorsal scale rows 25.

23. Light areas across back between the dark bars tinged with red in the mid-dorsal section; Cal.
Gerrhonotus multicarinatus multicarinatus (Blainville)
Red-backed or Keeled Alligator Lizard

Light areas grayish, untinged with red 24.

24. With eight rows of scales on base of tail keeled; Pacific States
Gerrhonotus multicarinatus scincicauda (Skilton)
Skink-tailed Alligator Lizard

With more than eight rows of scales on base of tail keeled; S. Cal.
Gerrhonotus multicarinatus webbii (Baird)
Webb's Alligator Lizard

25. Scales on upper part of foreleg mostly smooth 26.

Scales on upper part of foreleg mostly keeled 27.

26. Usually with fourteen complete lengthwise dorsal scale rows; tail dark spotted; Montana to Wash. and N. Cal.
Gerrhonotus coeruleus principis (B. & G.)
Northern Alligator Lizard

Usually with sixteen complete lengthwise dorsal scale rows; tail dark barred; adjacent mountain region of Oregon and Cal.
Gerrhonotus coeruleus shastensis Fitch
Shasta Alligator Lizard

27. Sides usually light flecked; Cal.
Gerrhonotus coeruleus palmeri (Stejneger)
Sierra Alligator Lizard

Sides with light bars; Cal.
Gerrhonotus coeruleus coeruleus (Wiegmann) Blue Alligator Lizard
(*Gerrhonotus burnettii* of Cope)

28. No eyelids; pupils vertical in bright light 29.
With movable eyelids; pupils round, except in *Coleonyx* 37.

29. Top of head with small, bead-like scales; Family *Gekkonidae* Geckos 30.
Top of head with large, flat scales; Family *Xantusiidae* Night Lizards 34.

30. Toes not flattened or swollen; S. Florida (introduced)
Gonatodes fuscus (Hallowell) Yellow-headed Gecko
Toes on hind feet flattened or swollen into pads 31.

31. Each hind toe flattened and swollen throughout length, with the claw projecting from the end of the toe; male with a row of pores lengthwise along the rear of the inner side of the thigh; introduced into Florida
Hemidactylus turcicus (Linn.) Leaf-toed Gecko
Each hind toe swollen at the tip, with the claw scarcely projecting beyond the end of the toe; no femoral pores 32.

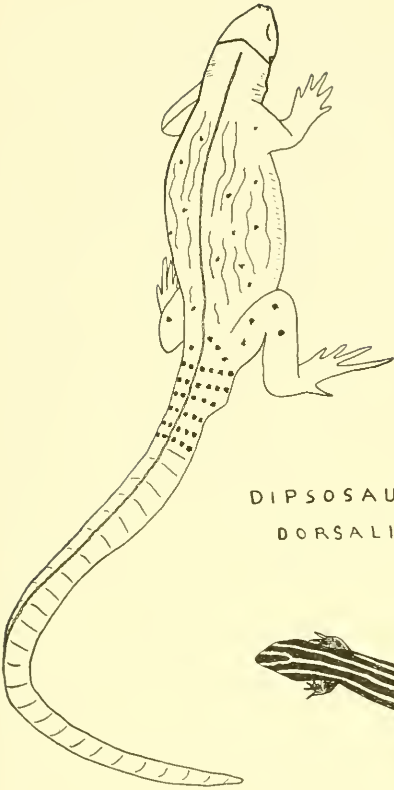
32. Swollen pad at tip of hind toe double, with the claw between the two parts of pad; with several rows of warts or tubercles along back and sides; grayish or yellowish above, with dark markings; Cal.
Phyllodactylus tuberculosus Wiegmann Warty Gecko
With a single swollen pad at the end of each toe; back evenly scaled; Florida 33.

33. Back dark, with yellowish spots
Sphaerodactylus cinereus Wagler Spotted Gecko
Back yellowish, with dark spots or lengthwise markings
Sphaerodactylus notatus Baird Reef Gecko

34. With two rows of small plates above each eye; with sixteen lengthwise rows of plates on the belly; hind legs almost half as long as the tail; on islands off the coast of Cal.
Xantusia riversiana Cope Island Night Lizard
Supraoculars in one row; with fourteen or less rows of plates on the belly; legs much shorter 35.

35. With fourteen rows of plates on belly; back brown, marked with light; S. Cal.
Xantusia henshawi Stejneger Boulder Night Lizard
With twelve rows of plates on belly; back yellowish, gray or brown, with dark dots 36.

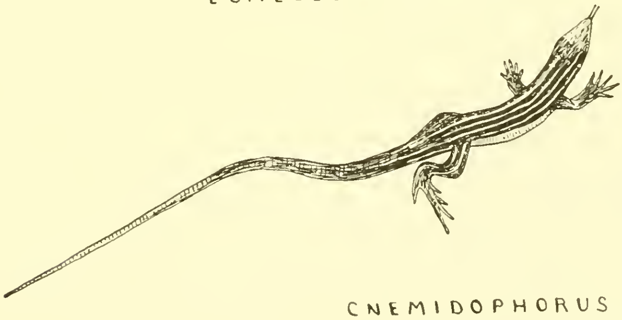
36. With more than 42 granular scales across back; with a dark band along side of head through the eye; Ariz.
Xantusia arizonae Klauber Arizona Night Lizard
With less than 42 granular scales across back; usually with a pale stripe on each side from the region of the eye backward on to the area above the shoulder; Utah to Cal.
Xantusia vigilis Baird Desert Night Lizard



DIPSOSAURUS DORSALIS

COLEONYX VARIEGATUS

EUMECES FASCIATUS



CNEMIDOPHORUS SEXLINEATUS

37. Toes of hind feet flattened and swollen into pads; Family *Iguanidae* (part) 38.
Toes not flattened or swollen 39.

38. Tail narrowed and with a mid-dorsal keel; Key West, Florida
Anolis stejnegeri Barbour Key Chameleon
Tail evenly cylindrical; southeastern states to Texas; introduced into Kansas
Anolis carolinensis Voigt American Chameleon, Fence Lizard

39. Entire head and body covered with large, bead-like tubercles; toes of hind foot of about equal length; color yellowish to reddish, marbled with dark; with poison glands in the lower jaw; Nevada, Utah and Ariz.; Family *Helodermatidae*
Heloderma suspectum Cope Gila Monster
Body scaled or granulated; toes of hind foot quite unequal; no poison glands 40.

40. With a single row of enlarged, keeled or spiny scales along the middle of the back; Family *Iguanidae* (part) 41.
Not so; sometimes with several lengthwise rows of enlarged scales 43.

41. Back with large, pointed scales; no femoral pores; introduced into Florida
Leiocephalus carinatus virescens (Stejneger) Bahama Crested Lizard
Back with small, flattened or keeled scales; males with femoral pores (a row of pores lengthwise along the rear of the inner side of the thigh); southwestern states 42.

42. With a throat fold, covered by smaller scales; mid-dorsal row of scales flattened and keeled; tail rather smoothly scaled; Nevada, Colo., Ariz. and Cal.
Dipsosaurus dorsalis (B. & G.) Desert Iguana
No throat fold; mid-dorsal row of scales in the form of upright spines; tail spinose; Lower Cal.
Ctenosaura hemilopha (Cope) Cape Iguana

43. Scales hard, flat, glossy; no femoral pores; Family Scincidae Skinks or Smooth-scaled Lizards 44.
Scales granular, or somewhat raised, dull; males with a row or rows of pores lengthwise along the rear of the inner side of the thigh (often very obscure and difficult to see) 62.

44. No internasal plates, the interfrontonasal projecting between the two nasals; with a bare spot on the lower eyelid; with a dark stripe lengthwise along each side; Ill. to Florida and Texas
Leiolopisma unicolor (Harlan) Ground Lizard
(*Leiolopisma laterale* (Say))
With two internasal plates; lower eyelid entirely scaly; color various, although often light striped 45.

45. With 18-22 rows of scales around the middle of the body; tail reddish 46.
With 24 or more rows of scales around the middle of the body; tail color similar or not so 47.

46. Light stripes running the length of the body; Ala., Georgia and Florida
Eumeces egregius (Baird) Eastern Red-tailed Skink
(*Plestiodon egregius* (Baird))
Light stripes on anterior part of body only; Florida
Eumeces onocrepis (Cope) Florida Red-tailed Skink

47. With a row of light spots along each side of the upper jaw; rows of scales on sides oblique, not parallel to the dorsal rows of scales; dorsal scales often light-spotted or dark-edged; Kansas to Utah, and southwards
Eumeces obsoletus (B. & G.) Spotted Skink
(Includes *E. guttulatus* (Hallowell))
Not so; upper jaw mostly light colored or dark blotched; rows of scales on sides parallel to the dorsal rows of scales 48.

48. Dorsolateral light lines on the third row of scales on each side (counting from the mid-dorsal line) and extending the length of the body 49.
Dorsolateral light lines absent or differently situated 50.

49. With two light lines only on the body; N. M. and Texas
Eumeces gaigeae (Taylor) Two-lined Skink
With more than two light lines on the body; with a mid-dorsal light line which forks on the head; adults with several light lines on each side; Neb. to Texas and Ariz.
Eumeces multivirgatus (Hallowell) Many-lined Skink

50. No postnasal (small plate not larger than the nasal behind the nasal and before the two larger plates (loreals) in a horizontal plane before the eye); with two or three median plates (one mental and one or two postmentals) from the tip of the chin backwards, before the chin shields begin; scale count 24-29 51.
With one postnasal; with three median plates (one mental and two postmentals) from the tip of the chin backwards; scale count various 56.

51. With at least traces of two diverging light lines on top of the head; dorsolateral light lines incomplete on posterior half of body or not dark bordered 52.
No light lines on top of the head; dorsolateral light lines distinctly dark bordered and extending the full length of the body 54.

52. Parietal plates on head adjacent behind the interparietal; Ariz.
Eumeces callicephalus Bocourt Mountain Skink
Parietal plates completely separated by the interparietal 53.

53. Dorsolateral light lines extending the full length of the body; light lines on top of the head usually not joining posteriorly; Texas
Eumeces tetragrammus (Baird) Texas Skink
Dorsolateral light lines fading out on posterior half of body; light lines on top of the head usually joining posteriorly; Texas
Eumeces brevilineatus Cope Short-lined Skink

54. With two median plates (one mental and one postmental) from the tip of the chin backwards, before the chin shields begin; dorsolateral light lines not dark-edged above; N. Y. to Ga. and Texas
Eumeces anthracinus (Baird) Black Skink

With three median plates (one mental and two postmentals) from the tip of the chin backwards; dorsolateral light lines dark-edged above 55.

55. With two dark lines along the center of the back; Minn. to Kansas
Eumeces septentrionalis septentrionalis (Baird)
Black-banded or Northern Prairie Skink

Dark lines along center of back obscure or absent; Kansas to Texas
Eumeces septentrionalis obtusirostris Bocourt
Southern Prairie Skink

56. Limbs, when pressed toward each other along the sides, widely separate; no light stripes; Texas and N. M.
Eumeces humilis (Boulenger) Taylor's Skink

Appressed limbs almost or quite touching; young with light stripes 57.

57. With five light stripes on the body (with a mid-dorsal stripe which forks on the head), except in adult males; dorsolateral stripes not involving the second row of scales from the mid-dorsal line; tail of young often blue; head of adult male often red or orange; scale count usually 28-32 58.

With four light stripes, the dorsolateral ones quite wide, involving the second and third scale rows, or unstriped in adult specimens; tail of young blue or red; scale count 24-28 60.

58. Dorsolateral light lines on third and fourth rows of scales (from midline); Atlantic States and Mississippi Valley
Eumeces fasciatus (Linn.) Common Five-lined Skink
(*Eumeces quinquelineatus* of Cope)

Dorsolateral light lines on fourth or fourth and fifth rows of scales 59.

59. Scales below tail narrow; mid-dorsal light stripe usually not joining the diverging light stripes on the head; Va. to Florida and Miss.
Eumeces inexpectatus Taylor Florida Five-lined Skink

Scales below tail much wider than deep; mid-dorsal light stripe forking on the neck to form two diverging stripes on the head; southeastern states to Oklahoma
Eumeces laticeps (Schneider) Giant Five-lined Skink

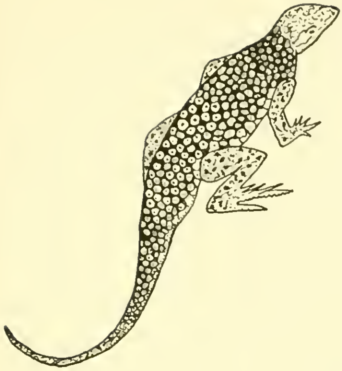
60. Tail of young red; interparietal about two times as long as wide; adults uniformly colored; Cal.
Eumeces gilberti rubricaudatus (Taylor)
Western Red-tailed Skink

Tail of young blue; interparietal much less than two times as long as wide 61.

61. Dorsolateral light stripe involving not over half the second row of scales; adults striped; Cal. to Wash. and Montana
Eumeces skiltonianus (B. & G.) Western Blue-tailed Skink
(*Eumeces quadrilineatus* Hallowell)

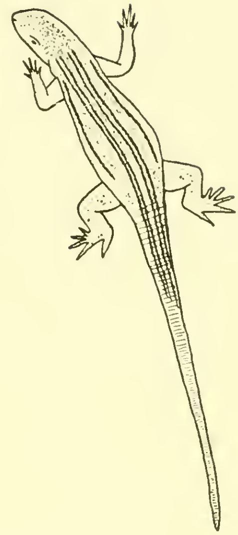
Dorsolateral light stripe involving over half the second row of scales; adults losing stripes; Cal. and Ariz.
Eumeces gilberti gilberti (Van Denburgh)
Gilbert's Blue-tailed Skink

62. Belly with large squarish plates in eight lengthwise rows; scales of back granular in appearance; young with a striped pattern, which may

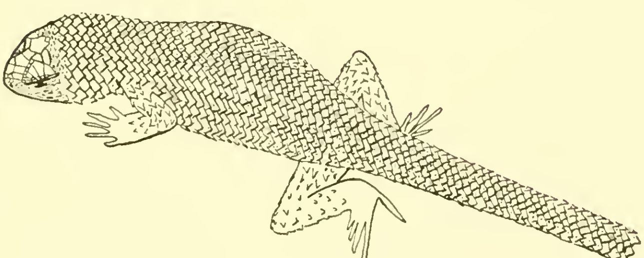


UMA NOTATA

HOLBROOKIA
MACULATA



UROSAURUS ORNATUS
SYMMETRICUS



SCELOPORUS ORCUTTI

become obscure or spotted in the adults of some species; Family *Teiidae.* Race Runners or Striped Lizards 63.

Scales of belly smaller and more numerous; without definite lengthwise stripes, except in some species with large, spiny scales 68.

63. With one frontoparietal plate on the head; southern and Lower Cal. and outlying islands
Cnemidophorus hyperythrus Cope Cape Striped Lizard

With two frontoparietals 64.

64. Scales on posterior edge of throat fold very small 65.

With enlarged scales on the posterior edge of the throat fold 66.

65. Color pattern in lengthwise stripes only; Utah to Texas
Cnemidophorus perplexus B. & G. Striped Race Runner

Adults usually with light bars on dark stripes to form a checker-board pattern; Colo. to Wash. and Cal.
Cnemidophorus tessellatus (Say) Tessellated Race Runner and varieties

66. With light bars on dark stripes in a checker-board pattern; Texas
Cnemidophorus grahamii B. & G. Tiger Race Runner

Sometimes light spotted, but not definitely light and dark barred 67.

67. With two light stripes (dorsolateral and one below it) on each side of the tail; no light spots on adults; Mississippi Valley, and Florida to Maryland and Ariz.
Cnemidophorus sexlineatus (Linn.) Six-lined Race Runner

With a single light stripe (dorsolateral) on each side of the tail; adults usually light spotted; Arkansas to Ariz., and southwards
Cnemidophorus gularis B. & G. Spotted Race Runner

68. Skin very soft, without obvious scales; no throat fold; pupil of eye vertical in bright light; toes without ridges below; about two to three inches long; Family *Gekkonidae* (part) 69.

Skin tougher; either with a throat fold or folds or with large, spiny scales; pupil of eye round; toes with lengthwise ridges below; often larger; Family *Iguanidae* (part) 70.

69. Tail with dark rings; with three to six femoral pores on rear of each thigh, with a space between the two series; N. M. and Texas
Coleonyx brevis Stejneger Lesser Banded Gecko

Tail dark barred above; with six to ten femoral pores on the rear of each thigh, forming a continuous V-shaped series; Utah to Cal.
Coleonyx variegatus (Baird) Variegated Banded Gecko

70. Scales along the edge of the upper jaw (upper labials) oblique and overlapping 71.

Upper labials upright and not overlapping 81.

71. No visible ear openings Spotted Lizards 72.

With visible ear openings 78.

72. With dark spots or bars on under side of tail 73.

No dark markings on under side of tail 74.

73. Tail mostly flattened; tail dark barred below; back usually with small

light dots in color pattern; with two dark bars posteriorly on each side, extending diagonally on both dorsal and ventral areas; Ariz. to Texas

Holbrookia texana (Troschel) Zebra-tailed Lizard

Tail flattened only at base; tail with a median row of dark spots below; no light dots in back pattern; no distinct dark bars on sides; Texas

Holbrookia lacerata Cope White-bellied Lizard

74. Dorsal scales each with a median, lengthwise keel; no blue tinge about the two dark bars on each side of belly of males; Texas

Holbrookia propinqua B. & G. Rough-scaled Spotted Lizard

Scales of back not keeled, although often with keeled scales on legs and tail; color characters various 75.

75. Back with many small light spots that obscure the rows of dark blotches; supraoculars (large scales covering region of the eyeball) usually adjacent to frontal plate; Ariz.

Holbrookia elegans Bocourt Slender Spotted Lizard
(*Holbrookia maculata thermophila* Barbour)

Back usually with a pattern of dark blotches in lengthwise rows, as well as scattered, small, light spots; with a row of tiny scales between the supraoculars and the frontal 76.

76. Tail usually well over length of head and body (to anus); Ariz.

Holbrookia pulchra Schmidt Mountain Spotted Lizard

Tail seldom much, if any, over length of head and body 77.

77. Usually with lengthwise light stripes between the rows of dark blotches; throat of male plain; no blue about dark bars on sides of belly; Wyoming and Nebraska to Texas and Ariz.

Holbrookia maculata maculata (Girard) Common Spotted Lizard

Less distinctly light striped; throat of male pigmented; with blue color about the dark bars on sides of belly; N. M. and Ariz.

Holbrookia maculata approximans (Baird) Rio Grande Spotted Lizard

78. Toes without spines; back usually grayish, with pale spots, and with dark spots or blotches in lengthwise rows; Nevada to Cal. and Ariz.

Callisaurus draconoides Blainville Gridiron-tailed Lizard
(Includes *C. ventralis* (Hallowell))

Toes each with a row of short, spiny scales, separated by tiny scales from the ventral toe plates; dorsal color usually in a regular black network enclosing small light areas, some of each of which may have a central dark dot 79.

79. With dark lines directed diagonally backwards on each side of throat, broadening and joining medianally to form dark, V-shaped or crescent-shaped markings; Cal.

Uma scoparia Cope Mohave Desert Lizard

Diagonal dark lines on throat fading out toward the mid-line 80.

80. With a dark blotch on each side of the belly; Ariz. and Cal.

Uma notata notata Baird Colorado Desert Lizard

Belly plain light colored; Cal., Riverside County

Uma inornata Cope Riverside Desert Lizard

81. No fold of skin across the throat, or with only slight indications of one; scales of back uniformly large and each ending in a spine posteriorly 82.

With a fold or folds of skin across the throat; larger, spiny scales may or may not be present on the back in lengthwise rows 101.

82. With a row of tiny scales extending about halfway back along the row of supraoculars, on the side away from the eye 83.

With a row of tiny scales completely bordering the supraoculars, on the side away from the eye 85.

83. Scales of back each deeply notched on each side of spiny tip; with a dark blotch on shoulder, but no distinct collar; Cal.

Sceloporus orcutti Stejneger Orcutt's Spiny Swift

Scales of back not each deeply notched on each side of spiny tip; with a dark "collar" on neck, which may be broken above 84.

84. Legs dark barred; scales of back fully keeled; N. M. and Ariz.

Sceloporus clarkii clarkii (B. & G.) Clark's Spiny Swift

Legs not dark barred; scales of back keeled about halfway from tips; Utah to Ariz. and Cal.

Sceloporus magister Hallowell Greater Spiny Swift

85. With indications of a gular fold on each shoulder; with small, granular scales on the sides; Texas 86.

No indications of a gular fold; with larger, overlapping scales on the sides 87.

86. Tail dark barred above; W. Texas

Sceloporus merriami merriami (Stejneger) Merriam's Canyon Swift

Tail ringed; Chisos Mts., Texas

Sceloporus merriami annulatus Smith Merriam's Ring-tailed Swift

87. With a dark, light-bordered band or "collar" across back of neck 88.

Not so 90.

88. Dark "collar" usually broken in the middle of the back of the neck; supraoculars (large scales covering the region of the eyeball) in one row, bordered on each side by smaller scales; Ariz. and N. M.

Sceloporus jarrovii Cope Yarrow's Swift

Dark collar complete across back of neck; supraoculars at least partly double, bordered on each side by smaller scales 89.

89. Usually with only one or two supraoculars double; general color bluish; Texas

Sceloporus cyanogenys (Cope) Blue Collared Swift

Supraoculars usually in two fairly complete rows above each eye; general color reddish; N. M. and Texas

Sceloporus poinsettii B. & G. Red Collared Swift

90. Scales on sides in horizontal series; usually with a light line lengthwise on each side of back passing through the center of a single row of scales; belly unmarked; one color phase is plain brown above; Ariz.

Sceloporus scalaris slevini Smith Mountain Swift

Scales on sides sloping upwards posteriorly; light lines, if present on back, wider 91.

91. With a slit-like depression just behind each hind limb; usually with a dorsolateral light stripe on each side of back enclosing two rows of dark spots, with a mid-dorsal light stripe between them; male with a large pink area on each side of belly; Texas
Sceloporus variabilis marmoratus (Hallowell)
Pink-bellied Swift

No slit-like depression so situated; pattern various; no pink areas on belly 92.

92. Usually about 30 ($\pm$3) scales along the back from the base of the head to a point opposite the hind margin of the hind leg; rear surface of thigh usually unmarked; N. M. and Texas
Sceloporus spinosus Wiegmann Texas Spiny Swift
(Includes *S. floridanus* Baird or *S. olivaceus* Smith)

Usually well over 30 scales along the back, or with a dark mark or markings on the rear surface of thigh 93.

93. With small, granular scales on rear surface of thigh; average scale count usually 48 or over; Colo. to Wash. and Cal.
Sceloporus graciosus B. & G. Sage Brush Swift
(and subspecies)

With larger, overlapping scales on rear surface of thigh; average scale count usually under 48 94.

94. Fourth toe of hind foot extremely long — almost twice as long as the third toe; with a broad dark band along each side; Florida
Sceloporus woodi Stejneger Florida Pine Lizard

Fourth toe not greatly longer than third toe 95.

95. Scales of back not noticeably larger posteriorly, gradually blending in size into those of sides; westward from Kansas (Two common subspecies of *S. occidentalis* given here) 96.

Scales of back larger posteriorly than those of sides; eastward from Nevada (Variations of *S. undulatus*) 97.

96. Supraoculars (large scales covering area of eyeball) in two rows; throat of male with median blue color; Wyoming to Wash. and Cal.
Sceloporus occidentalis biseriatus (Hallowell)
Western Fence Lizard

Supraoculars in one row; throat of male with blue coloring on each side; Wash. to Cal.
Sceloporus occidentalis occidentalis (B. & G.)
Pacific Fence Lizard

97. Usually with two light stripes (dorsolateral and one below it) on each side 98.

Back relatively unstriped or with dorsolateral stripes only 99.

98. Males with blue color on each side of throat; each thigh usually with more than fifteen femoral pores; western N. D. to western Texas
Sceloporus undulatus consobrinus (B. & G.)
Southern Prairie Swift

No blue throat color; each thigh usually with less than fifteen femoral pores; S. D. to Okla.

Sceloporus undulatus garmani (Boulenger)
Northern Prairie Swift

99. Average scale count over 45; Colo. to Nevada and Ariz.
Sceloporus undulatus elongatus Stejneger Colorado Swift
Average scale count under 45 100.

100. Average scale count over 38; Georgia to Maryland and Ind.; Texas
Sceloporus undulatus fasciatus (Green) Northeastern Fence Lizard
(*Sceloporus undulatus hyacinthinus* (Green))
Average scale count under 38; La. to S. C.
Sceloporus undulatus undulatus (Latreille)
Southeastern Fence Lizard, Pine Swift

101. Tiny scales in a row directly above the eye upright and not overlapping; tail thick and blunt, not longer than head and body; Utah to Cal. and Ariz.
Sauromalus obesus (Baird) Chuckawalla
(*Sauromalus ater* of Cope)
Superciliary scales oblique and overlapping; tail, when entire, narrow and longer than head and body 102.

102. Plates on top of head small 103.
Plates on top of head larger, the interparietal being larger than the ear opening 107.

103. With several lengthwise rows of scales on top of the head between the area of the eyeballs; rostral plate three to four times as wide as the labial on each side of it 104.
With one or two lengthwise rows of scales on top of the head between the area of the eyeballs; rostral plate twice as wide as the labial on each side of it 105.

104. Young light barred; adults dark blotched only; head wider than distance from nostril to ear opening; Oregon to Texas and Cal.
Crotaphytus wislizenii B. & G. Common Leopard Lizard
(*Gambelia wislizenii* (B. & G.))
Back with several light cross bars in both young and adults; head not wider than distance from nostril to ear opening; Cal. to Wash.
Crotaphytus silus Stejneger Barred Leopard Lizard

105. With a light network on the back; with only faint traces of bands around the neck, or these are often absent; Texas and La.
Crotaphytus reticulatus Baird Reticulated Lizard
With light spots on the back; with two black bands around the neck 106.

106. Scales on top of the head between the area of the eyeballs mostly in one row; throat of male plain; Mo. to Texas and N. M.
Crotaphytus collaris collaris (Say) Eastern Collared Lizard
With two complete rows of scales on top of the head between the area of the eyeballs; throat of male with dark markings; Idaho to Cal. and Texas
Crotaphytus collaris baileyi (Stejneger)

107. Scales of back equal or blending in size 108.
With lengthwise rows of raised or enlarged scales dorsally or with dorsolateral folds 109.

108. Scales of back small, smooth; back with light spots and dark cross bands which tend to extend on to the belly; S. Cal.
Streptosaurus mearnsi (Stejneger) Banded Swift
(*Uta mearnsi* Stejneger)
Scales of back keeled, larger than lateral scales; back with light spots and often with faint, light, lengthwise stripes; Wash. to Cal. and Texas
Uta stansburiana B. & G. Ground Swift
(and subspecies)

109. Frontal plate entire; scales along center of back all small (between a raised dorsolateral line on each side); Cal.
Urosaurus microscutatus (Van Denburgh) Small-scaled Swift
Frontal plate divided; scales of back (between dorsolateral ridges) in large and small lengthwise series (*U. ornatus* — six of the eight subspecies are given here) 110.

110. Tail very long, twice as long as head and body; with several nearly equal rows of enlarged scales down middle of back; Nevada, Ariz. and Cal.
Urosaurus ornatus graciosus Hallowell Long-tailed Swift
(*Uta graciosa* (Hallowell))
Tail shorter; with a mid-dorsal series of very small scales, bordered on each side by two to four lengthwise rows of larger scales 111.

111. Dorsolateral folds absent or almost so; large dorsal scales scarcely keeled; N. M.
Urosaurus ornatus levis (Stejneger) Olive Swift
With distinct dorsolateral folds or with some large dorsal scales well keeled, or both 112.

112. With two fairly regular rows of large dorsal scales on each side of the small mid-dorsal series; scales of sides in parallel, diagonal rows 113.
Large dorsal scales more irregularly arranged or in more rows; scales of sides not in regular, diagonal series 114.

113. Mid-dorsal series of small scales wider than any individual large, dorsal scale; Cal. and Ariz.
Urosaurus ornatus symmetricus (Baird) Symmetrical Swift
Mid-dorsal series of small scales narrower; Ariz. and N. M.
Urosaurus ornatus linearis (Baird) Lined Swift

114. Usually with one to two irregular rows of large scales on each side of the small mid-dorsal series; usually with a fold of skin along each side below the dorsolateral fold; Texas
Urosaurus ornatus ornatus (B. & G.) Common Ornate Swift
Usually with two to three irregular rows of large scales on each side of the small mid-dorsal series; sides fairly smooth below the dorsolateral folds; Utah, Colo., Ariz. and N. M.
Urosaurus ornatus wrighti (Schmidt) Wright's Ornate Swift
(*Uta wrighti* Schmidt)

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The names used as first choice in the lizard key are those given in the fifth edition of Stejneger and Barbour's Check List.

SNAKES

CHAPTER 12

An extreme and largely unjustified prejudice exists against snakes. This is apparently another example of the principle that we distrust whatever we do not understand. It is well to beware of snakes until one has learned which ones are poisonous, but fortunately these are limited to two groups, rattlesnakes and copperhead, in the states north of 40° latitude. South of this two others, water moccasin and coral snakes, are also found. Most snakes are inoffensive or beneficial animals, streamlined for pursuing insects, rodents and other prey. The visits snakes pay to barns and outdoor cellars are usually in search of mice.

A few of the lizards, a related group of reptiles, lack limbs and bear a close resemblance to snakes. The most common of these lizards, the glass snake, may be distinguished from the snakes by the presence of movable eyelids and external ear openings. The others are less readily identified as lizards. In order to avoid confusion in this regard, the legless lizards have been included in the snake key as well as in the preceding chapter.

The poisonous snakes of wide distribution are the pit-vipers—the rattlesnakes, the copperhead and the moccasin or cotton-mouth. These all have vertical pupils or cat-like eyes, the mark of crepuscular or twilight-roaming animals. They are not likely to be encountered abroad during full daylight, except for short intervals in the spring or fall, as they are leaving or seeking hibernation quarters. Another distinguishing character of these snakes is the presence of a deep "dimple" or pit on the side of the head halfway between the eye and the nostril. They also differ from most of the other snakes in having most of the subcaudal plates undivided. The poison fangs are hollow, like hypodermic needles, and are situated in the front of the upper jaw. They are folded back against the roof of the mouth when not in use. The poison injected into the victim by one of these snakes acts on the haemoglobin of the blood.

The rattlesnake is readily recognized in the field by the presence of "rattles" on the end of the tail, which in motion produce a noise much like that made by a cicada. Many harmless snakes simulate this sound by buzzing the tail among sticks or dry leaves. The copperhead may be identified by the "hour-glass" back markings, narrowest on top, and by the lack of markings on top of the head. The harmless milk snake or checkered adder, so often mistaken for the copperhead, has its back blotches widest on top and usually has a yellow, Y-shaped marking on its neck and an additional spot or two on its head. The cotton-mouth is commonly confused with the brown water snakes of the genus *Natrix,* which bite readily but are not poisonous. It is found from Indiana and Illinois southward.

In the southern states the coral snakes are occasionally turned up by the plow or more rarely seen above ground. They are nocturnal members of the cobra family and, but for their small size, would be most dangerous. The poison, like that of the dreaded cobra, acts on the nervous system. The hollow poison fangs are set rigidly in the front of the upper jaw. The "warning" coloration of red, yellow and black rings has been adopted by several non-poisonous snakes, but the latter either have the rings incomplete on the ventral surface or else do not have the red and yellow color adjoining.

There are several other snakes that possess poison glands but lack the fang development for injecting it efficiently. These, such as *Tantilla* and *Trimorphodon,* are classed as semi-poisonous snakes. Their grooved, poison-conducting teeth are situated in the back part of the mouth and seldom cause dangerous injury to man.

Most of us have been thrilled by stories of gigantic boa constrictors or by the "boas" of the circus side show, which are often in reality pythons, larger members of the same family. Two genera of boas are found in the southwestern United States, but they are both small compared with their tropical relatives. Like the pit-vipers, they differ from the other snakes in having vertical pupils and undivided subcaudal plates. The rosy boa is rare and little is known of its habits. The rubber snake is fairly common within its range. Like the larger representatives of the family, it kills its prey by encircling and crushing it.

Snakes are all carnivorous, most of them eating only the animals they capture and usually refusing to accept anything but live food, even in captivity. Garter snakes, green snakes and little brown snakes live largely on earthworms and insects. Water snakes eat frogs, crayfish and occasional warm-blooded prey. The viperine snakes, (rattlesnakes, copperhead and water moccasin), colubers, and whip snakes and racers feed mostly on warm-blooded animals, chiefly mice. Some snakes may even follow rats or mice into their burrows in order to capture them. All snakes swallow their prey whole, the bones of the jaw being so hinged that the lower jaw drops down and the halves spread apart. An object three or four times the diameter of the snake can be thus engulfed. Once past the neck region powerful muscles crush the food into a more easily manageable mass. Even hen's eggs may be so manipulated and not crushed until they are beyond danger of loss by spilling.

Contrary to general impressions snakes do not mate for life nor travel always in pairs. Favorable territory frequently supports several snakes of the same species, so that some valiant snake-killer, having destroyed one and being convinced that its mate is near by, can usually find another to support his theory. Actually there is little evidence of family life or interest in other members of the species except at times of mating and of hibernation. The poisonous snakes, water snakes, garter snakes and little brown snakes retain their eggs within the body until hatching time, so that they bring forth living young. Most of the other snakes seek suitable spots in which to deposit their eggs, but pay them no further attention. A few snakes are known to brood their eggs and the brooding habit may be more general than is supposed. The black snakes and racers seek manure piles or decaying straw stacks for egg-laying, possibly because the moisture and heat of fermentation afford ideal conditions for incubation. The green snakes and most of those preferring uncultivated and rocky country usually deposit their eggs under flat stones, which absorb heat during the day and act like old-fashioned soapstones to keep the eggs warm during part of the night. In most cases the young closely resemble the adults, but in a few cases where the adults are of uniform color the young may show a distinct pattern. The latter condition is true of the black snake and of several of the other racers.

It is a common occurrence to find the discarded skin of a snake. Most snakes leave the skin turned inside out, but entire and unbroken. Sometimes it is possible to identify a snake to genus or even to species by the scalation of the shed skin. The rattles of the rattlesnake are formed at the times of shedding. The number of rattles is no definite indication of the age of the snake, however, as the skin may be shed several times a year. The rattles are often lost, so that a very old rattlesnake may possess only a few rattles.

One of the most amazing actors among the snakes is the spreading adder, *Heterodon*. When alarmed, it raises the front part of its body into the air and flattens out its neck region much like a cobra. Its evil appearance is then supplemented by a loud hissing and all the preliminaries of an attempt to strike. If one is bold enough to call its bluff and offer it a hand for a target, he will find its strikes are so measured as to fall just short of the apparent goal. If struck, the snake will exhibit another more spectacular stunt. A shudder runs along its body, its jaws gape widely and its tongue lolls out, so that it appears to be having an epileptic fit. After a little of this it remains perfectly limp, belly up, and apparently dead. Only one flaw mars its performance. Apparently convinced that a dead snake lies always upon its back, it will quickly flop back in that position if it is turned upon its belly. The snake lies motionless as long as danger is apparent. When all appears quiet, it slowly raises and turns its head, always ready to fall back at a moment's notice. Satisfied that all is well, it rights itself and moves quietly away.

The general aversion to snakes has led to the acceptance of many fallacious stories concerning them. The average person who encounters a snake does not tarry long enough to make close observations, and his descriptions come to be colored by imagination rather than fact.

No snake ever rolls itself down hill in hoop form. Tree-climbing snakes, such as the black snake, frequently fling themselves from a tree into the underbrush, when disturbed, and a nervous and excited observer may easily convince himself that he has seen a hoop snake.

Milk snakes do not suck cows dry, as is often reported, but frequent barns to seek for mice.

No scientist or person friendly toward snakes has ever seen them swallow their young in order to protect them. Because of the peculiarities of snake anatomy, unborn snakes may appear to the casual observer to be in the parent's stomach. Some snakes do eat smaller snakes. However, digestive juices that are able to dissolve even bone would make a snake's stomach an extremely poor refuge.

Snakes have no hypnotic powers. Animals, like humans, may be too frightened to retreat from danger. Most reported cases of a snake's charming its prey deal with birds, which frequently flutter before any animal that approaches their nest in order to lead it away.

A wide, flat, triangular head does not brand a snake as poisonous. The harmless spreading adder, *Heterodon,* can flatten its head more than the dangerous water moccasin. The poisonous coral snakes have slender heads.

The forked tongue of a snake is harmless and apparently serves to pick up sound vibrations to supplement the poorly developed ears. The poisonous snakes have a pair of hollow teeth with which they stab to inject poison.

Removing the poison fangs does not render a snake harmless. New fangs soon grow in and the other smaller teeth inside the mouth may serve to introduce the poison. The poison sacs themselves can seldom be removed without fatally injuring the snake.

The rattlesnake usually gives warning before striking, but it may strike without rattling or coiling. Its strike usually does not exceed a distance equal to the length of the snake.

The prairie rattler does not live peaceably with prairie dogs, as is often reported, but seeks them for food.

Snakes are not slimy. Their skins are dry, but may feel rather clammy, since their temperature is usually below that of the human body.

Fear of snakes is not instinctive. All animals regard an unusual animal with caution. Children who have not been alarmed by the stories of their elders will handle a snake as readily as they will a guinea-pig.

Contrary to the usual stories, few snakes enjoy basking in summer sunshine. In cool weather or in high altitudes where the temperature is low, they may expose themselves, but in hot places they show no inclination to compete with the "mad dogs and Englishmen" of the old song. Studies being carried on by the American Museum and other investigators show that even the sidewinder, a rattlesnake considered to be well adapted to hot deserts, is killed by a few minutes' exposure to sunshine at a temperature of 100° F. and shows evidences of discomfort at temperatures much over 90° F. Most snakes die within twenty minutes if exposed to sunshine at 100° F.

It is not true that a snake will not pass over a rope, especially a hair rope, as is sometimes stated.

There are actual sea serpents, many kinds and many poisonous ones, with flattened tails to assist their swimming. None of them get to be as large as the big land snakes, however. The recurring reports of gigantic sea serpents are probably based upon fleeting glimpses of sharks, whales, and other common marine animals.

Study of Snakes

As a first step, the distinguishing characters of the local poisonous snakes should be carefully learned. Too much dependence should not be placed on color or pattern, since albinistic and melanistic variations are not rare, and at least one case of a completely black coral snake has been reported. Fortunately, the native poisonous snakes are seldom aggressive, and usually retreat if given any opportunity. Except in rare instances, most of the danger lies in inadvertently stepping on one, grasping it, mistaking it for a harmless one, or taking needless chances with one in order to impress observers.

Hunting for snakes.

Snakes are seldom easy to find, unless one happens upon a hibernation area at the right time in spring or autumn. During the rest of the year they must be sought out, usually in places of concealment under rocks, logs, brush piles, and similar locations. Water snakes can sometimes be captured at night, with the aid of a flashlight.

Catching snakes.

The often mentioned forked stick is of little practical value, because one can seldom take time to place it in position and it is likely to injure the snake. A plain stick is good, since one can usually hold it across the reptile, while one grasps the snake by the neck. A short hook or angle iron at the end of a stick is often useful in gently pulling a snake from a brush pile or rock crevice. The commonly suggested arrangements of strap or wire nooses are fine in theory but seldom of much value in the field. A pair of soft leather gloves will give one greater confidence and afford protection from the short teeth of the non-poisonous species. Once captured, the snake should be dropped into a cloth bag, the neck of which can be tied upon itself or with cord. This bag and its contents should never be left in the sun or on the floor of an automobile, or the occupant may die of heat.

Handling Snakes.

After the first handling, most snakes are quite docile, as long as they are not squeezed. The chief trick in handling a snake is to support, but not grasp, it. If it is active, it should be allowed to pass from one hand to the other. A snake should not be teased for, like a dog, it may become irritable and untrustworthy.

Identification of snakes.

Scale arrangement, especially on the head, offers the surest method of identification. The diagrams show the names and positions of the head scales. The body scales must also be counted, at times. Care should be taken to select a region about the middle of the body for counting the *number of scale rows,* as tapering toward the neck and tail region is usually accompanied by the dropping out of a few rows of scales. The count should be begun at the first scale above the broad ventral plates, and carried along the diagonal across the dorsal region to the opposite side. The *subcaudal plates* are often in pairs, in which case the count is still made from anus to tail tip, each pair therefore counting as one.

The color pattern is less reliable, but considerably more readily observed, especially on living, active specimens. Markings on the head and neck are often helpful and more constant than those on the back. For example, the lack of markings on top of the head of the copperhead sets it apart from the milk snake, which is often mistaken for it. In the United States the lengthwise striped snakes are not poisonous, but more caution should be observed in handling barred or blotched ones. It must be remembered that occasional black or very light specimens of any species, including the poisonous ones, may be found, and also that the pattern becomes very much obscured as a snake reaches the time when its skin is about to be shed. The pattern changes with age in some species.

Total length is the straight distance from the end of the snout to the tip of the tail. *Length of tail* is measured from the anus to the tip of the tail.

Keeping snakes.

Snakes can be kept in simple cages, but these should be clean and dry. A dish of water should be available, and a rock or other rough object should be provided, against which the reptile can rub itself to relieve irritations or aid in shedding its skin. The cage must be covered, since most snakes can reach surprisingly high and pull themselves out of any box, once they get their chins over the top. Ventilation should be provided by some such means as tacking strong screen wire over suitable openings. Some snakes, such as the black snake, can deliver surprisingly strong blows with the head, and may break ordinary window glass. They can also exert much lifting power, and will raise an unfastened lid. One good arrangement is to have a box provided with screened ventilating holes and with a triple-thick or plate glass side or roof sliding in grooves.

Feeding snakes.

Natural food should be provided, unless the snake learns to take meat dangled or shaken before it. Garter snakes take earthworms readily; the small brown and green snakes will usually take smooth caterpillars and small grasshoppers; water snakes, hog-nosed snakes and large garter snakes take frogs readily; most of the other common snakes prefer warm-blooded prey and will eat mice. A meal a week will maintain a snake in good condition. At low temperatures it can go for several months without food. If it refuses to eat for several weeks in warm weather, it is usually best to release it, unless it is a particularly valued specimen. Force-feeding is likely to result in injury.

Injuries and pests.

Injuries often result from a snake's striking at the glass or wire front of its cage, when teased or annoyed. This habit can be discouraged by covering the cage until the animal becomes used to its cage. If infection sets in, any mild antiseptic, such as potassium permanganate solution, may be applied. Ticks and other skin pests sometimes work under the scales and should be removed and the spots touched with antiseptic. If the reptile is unable to shed its skin completely, it may be aided gently with the fingers, or treated with warm water to help loosen the skin.

PROBLEMS FOR STUDY

Hibernation.

Field studies would shed much light on when and where each species of snake hibernates. Some are known to bury themselves under leaves and debris, others seek deep rock crevices which may dip beyond the reach of frost, and some have been reported to bury themselves in springs which do not freeze. Where snakes are common, records of the last time they are seen in the fall and of first appearance in spring would shed some light on the length of the hibernating season.

Reproduction.

Mating habits, place of deposition and number of eggs, length of incubation period under normal conditions, brooding habits and any evidences of parental interest in young are all topics needing further investigation. Some of these, such as incubation of eggs, can be studied under experimental or captive conditions, although field observations are preferable.

LIFE HISTORIES.

Among the subjects imperfectly known are rate of growth under normal and favorable conditions, time taken to reach sexual maturity, frequency of shedding of skin, amount of wandering or adherence to a definite range, and records of longevity. It is possible to mark snakes for future identification by snipping into one or more of the ventral plates. A scar or scars result which persist throughout life.

FOOD HABITS.

These are difficult to study without sacrificing many animals. Unfortunately the digestion of snakes is so efficient that the feces usually contain little identifiable material. However, one may sometimes observe the attempts of free snakes to swallow unusual or unexpected prey. Also, one can investigate the stomach contents of reptiles killed by automobiles or unsympathetic people. A surprising number of snakes can sometimes be picked up on state highways. The author secured only slightly damaged specimens of twelve different species on paved roads during a summer's automobile trip from Massachusetts to Iowa. In the southern states the number of snakes available in this way is even greater.

OUTLINE OF CLASSIFICATION OF NATIVE SNAKES

Order SQUAMATA (of Class REPTILIA)

With one temporal opening on each side, between parietal and the squamosal-postorbital bar; with one occipital condyle; no uncinate processes on ribs; no epipubic bones

Suborder SERPENTES Snakes

Brain case completely ossified; all skull bones except those of the brain case articulated; usually without traces of limbs or girdles

Family LEPTOTYPHLOPIDAE Blind Snakes

Small, blind, worm-like, burrowing snakes; belly of native species with small scales instead of ventral plates

One genus — *Leptotyphlops* (2 species)

Family BOIDAE Boas

Smooth-scaled; native species with vertical pupils and short, obtuse tails, with undivided subcaudal plates

Two genera — *Lichanura* (1 species)
Charina (1 species)

Family COLUBRIDAE Colubrine Snakes

An extremely large and varied group, with over one hundred native species; pupil round; scales smooth or keeled; no elongate poison fangs among the front teeth, but in a few forms some of the back teeth are long and grooved to form poison fangs; with divided subcaudals in all genera except *Rhinocheilus*

Thirty-six genera —

Carphophis (1 species)	*Contia* (1 species)
Abastor (1 species)	*Sonora* (5 species)
Farancia (1 species)	*Ficimia* (2 species)
Diadophis (3 species)	*Chilomeniscus* (3 species)
Rhadinaea (1 species)	*Natrix* (13 species)
Heterodon (3 species)	*Seminatrix* (1 species)
Opheodrys (2 species)	*Storeria* (3 species)
Coluber (5 species)	*Haldea* (2 species)
Drymobius (1 species)	*Liodytes* (1 species)
Drymarchon (1 species)	*Thamnophis* (9 species)
Salvadora (3 species)	*Tropidoclonion* (1 species)
Phyllorhynchus (2 species)	*Coniophanes* (1 species)
Elaphe (10 species)	*Oxybelis* (1 species)
Arizona (1 species)	*Leptodeira* (1 species)
Pituophis (5 species)	*Hypsiglena* (1 species)
Lampropeltis (7 species)	*Trimorphodon* (3 species)
Stilosoma (1 species)	*Tantilla* (8 species)
Cemophora (1 species)	*Rhinocheilus* (1 species)

Family ELAPIDAE Coral Snakes

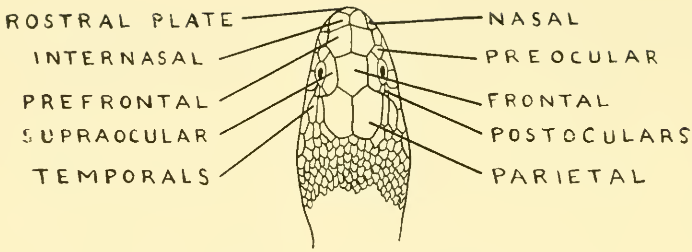
Pupil round; front pair of upper teeth forming short, rigid, poison fangs; native species with small eyes and body ringed with red, yellow and black; with divided subcaudals

Two genera — *Micrurus* (1 species)
Micruroides (1 species)

Family CROTALIDAE Pit-vipers

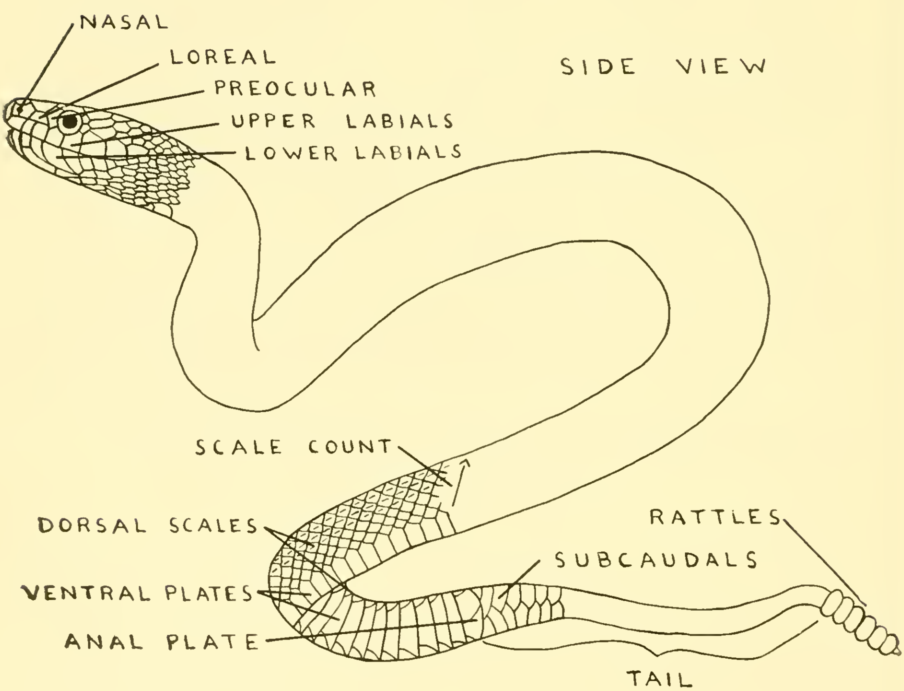
Pupil vertical; with a deep pit between eye and nostril; with a pair of long, hollow, poison fangs in front part of roof of mouth, folded against roof when not in use; with undivided subcaudals

Three genera — *Agkistrodon* (2 species)
Sistrurus (2 species)
Crotalus (13 species)



TOP OF HEAD

DIAGRAM OF A SNAKE



KEY TO THE PRINCIPAL SPECIES OF SNAKES AND LEGLESS LIZARDS

1. Ventral scales small, not conspicuously different from the dorsal scales, or apparently scaleless 2.
   Ventral scales larger than the dorsal scales and much lengthened crosswise 11.

2. With external ear openings; with a fold of skin lengthwise along each side; Va. to Wis.. southward to Fla. and N. M.
   Ophisaurus ventralis (Linn.) Glass Snake
   (A legless lizard)
   No external ear openings; no fold of skin along each side 3.

3. Scales inconspicuous; body with external rings, appearing like an earthworm; no visible eyes; Fla.
   Rhineura floridana (Baird) Florida Worm Lizard
   (A legless lizard)
   Body without external rings; with traces of eyes and with visible scales 4.

4. Upper jaw pointed and not projecting much beyond the lower jaw; eyes as lengthwise slits; with about five large plates side by side in front of anus; California (Legless lizards) 5.
   Upper jaw blunt and rounded and projecting much beyond the lower; eyes round and covered with thin skin; with only one large transverse plate before the anus; Family *Leptotyphlopidae* Blind Snakes 6.

5. Back silvery or buff
   Anniella pulchra puchra Gray Silver California Worm Lizard
   Back dark brown
   Anniella pulchra nigra Fischer Black California Worm Lizard

6. With three small plates side by side on top of the head between the plates containing the eyes 7.
   With only one transverse plate on top of the head between the plates containing the eyes 8.

7. With an undivided upper labial between the nasal and the descending plate (ocular) surrounding the eye; Okla. and Texas
   Leptotyphlops dulcis dulcis (B. & G.) Texas Blind Snake
   (*Glauconia dulcis* (B. & G.))
   With a divided upper labial so situated; Texas and Ariz. to Kansas
   Leptotyphlops dulcis dissectus (Cope) Prairie Blind Snake

8. With five light-colored rows of scales along the middle of the back; Cal. and Ariz.
   Leptotyphlops humilis cahuilae Klauber Desert Blind Snake
   With seven dark-colored rows of scales along the middle of the back 9.

9. With ten rows of scales on tail; Texas
   Leptotyphlops humilis segregus Klauber Mexican Blind Snake
   With twelve rows of scales on tail 10.

10. Mid-dorsal scale count less than 287; fifth mid-dorsal scale scarcely wider than sixth; Cal., Nev. and Utah
    Leptotyphlops humilis humilis (B. & G.) California Blind Snake

Mid-dorsal scale count over 287; fifth mid-dorsal scale much wider than sixth; Utah
Leptotyphlops humilis utahensis Tanner Utah Blind Snake

11. With most or all of the large plates on the lower surface of the tail single; mostly poisonous snakes 12.
With most of the large plates on the lower surface of the tail divided into two (sometimes with a few single plates); few poisonous and many harmless snakes 49.

12. With a deep pit between the eye and the nostril; pupil of eye vertical; with a pair of hollow poison fangs, which are folded against the roof of the mouth when not in use; Family *Crotalidae* Pit-vipers 13.
No pit between the eye and the nostril; pupil vertical or round; no poison fangs 44.

13. No rattles on tail 14.
With rattles on the end of the tail 19.

14. No loreal; with one of the upper labials reaching up to the eye 15.
With loreal; with two or three small scales between the eye and the upper labials 16.

15. End of snout dark; contrast between cross bands and ground color more evident in adult than in young specimens; Ill. to Ala. and Texas
Agkistrodon piscivorus leucostoma (Troost)
Western Water Moccasin, Cottonmouth
End of snout light, with a vertical dark bar on each side of rostral plate; contrast between cross bands and ground color more evident in young than in adult specimens; Va. to Ala. and Fla.
Agkistrodon piscivorus piscivorus (Lacépède)
Eastern Water Moccasin, Cottonmouth

16. Dorsal dark cross bands deeply hour-glass shaped, and not confluent with dark belly markings (See note at end of chapter) 17.
Dorsal dark cross bands scarcely hour-glass shaped, and confluent with dark belly markings 18.

17. Narrowed area of dorsal bands about three to five scales wide, never absent; color rather dark; Miss. to Ala. and Neb.
Agkistrodon mokeson mokeson (Daudin)
(*Agkistrodon mokasen* Beauvois)
(*Ancistrodon contortrix* (Linn.))
Northern Copperhead, Highland Moccasin, Chunkhead
Narrowed area of dorsal bands less than three scales wide or sometimes entirely absent, so that some of the cross bands are usually broken on the mid-dorsal line; color rather pale; Texas to Ill. and southern Atlantic states, except Florida
Agkistrodon mokeson austrinus Gloyd and Conant
Southern Copperhead

18. Cross bands broad and fairly regular, blending into color on sides of belly; Kansas to Texas
Agkistrodon mokeson laticinctus Gloyd and Conant
Western Copperhead

Cross bands irregular and usually with a light U-shaped area on each side; belly mostly dark, with sharply contrasting light areas; Texas
Agkistrodon mokeson pictigaster Gloyd and Conant
Texas Copperhead

19. Top of head between and a little behind the area of the eyeballs with about three large plates Pigmy Rattlesnakes 20.
Top of head between the area of the eyeballs with many small scales Larger Rattlesnakes 24.

20. Looking at the head from the side, with one plate above the pit and before the eye; usually with a light stripe from below the middle of the eye to the corner of the mouth 21.
With two plates, one above the other, above the pit and before the eye; usually with a light stripe from below the front of the eye to the corner of the mouth 23.

21. With about 25 rows of dorsal scales; ground color very dark; Fla. to Miss.
Sistrurus miliarius barbouri Gloyd Florida Ground Rattler
With about 21 rows of dorsal scales; ground color gray or brown 22.

22. With about 30 dark, mid-dorsal blotches; Mo. to Texas, also to Tenn. and Miss.
Sistrurus miliarius streckeri Gloyd Western Ground Rattler
With over 35 dark, mid-dorsal blotches; N. C. to Ala.
Sistrurus miliarius miliarius (Linn.) Eastern Ground Rattler

23. Belly mostly dark; N. Y. to Minn. and Kansas
Sistrurus catenatus catenatus (Raf.) Eastern Massasauga
Belly mostly light; Neb. to Ariz. and Texas
Sistrurus catenatus edwardsii (B. & G.) Western Massasauga

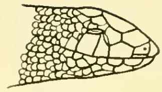
24. With a conspicuous spine or horn above each eye; Utah to Ariz. and Cal.
Crotalus cerastes Hallowell Horned Rattler, Sidewinder
No spine or horn above each eye 25.

25. With two large plates, about the size of the eyes, occupying the entire transverse area on top of the snout between the front corners of the eyes; tail usually dark; Ariz. to Texas
Crotalus molossus molossus (B. & G.) Black-tailed or Dog-faced Rattlesnake
With several small scales or plates in this region; tail banded or striped except in one species, which may have a dark tail 26.

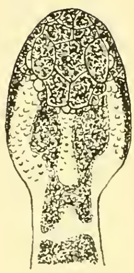
26. Looking at the head from the front, with the single large plate at the end of the snout (rostrum) separated from the large plate before each nostril by small scales; color whitish, dark dotted; Nev. to Ariz. and Cal.
Crotalus mitchellii pyrrhus (Cope) White Rattlesnake
With the rostral plate in contact on each side with the large plate before each nostril; color dark or pale 27.

27. End of snout sharply keeled; usually with an upright light bar on the rostrum; end of tail lengthwise striped; Ariz.
Crotalus willardi Meek White-banded Rattlesnake

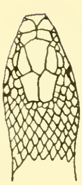
RHINEURA FLORIDANA



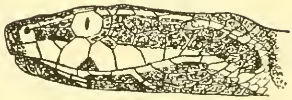
ANNIELLA PULCHRA



SISTRURUS CATENATUS CATENATUS



SALVADORA GRAHAMIAE



AGKISTRODON PISCIVORUS

End of snout indistinctly keeled; no light bar on rostrum; tail dark or barred 28.

28. With a vertical division in the upper preocular; snake greenish, with narrow, widely separated, dark cross bars along entire length 29.
Upper preocular entire; coloration not so 30.

29. With a dark line from the eye to the corner of the mouth; Texas
Crotalus lepidus lepidus (Kennicott) Rock Rattlesnake
No dark line from the eye to the corner of the mouth; Ariz. and N. M.
Crotalus lepidus klauberi Gloyd Green Rattlesnake

30. With several internasals (between the nasals and behind the rostrum) 31.
With two internasals 36.

31. With a dark band passing obliquely backwards on each side of the head from below the center of the eye to about the corner of the mouth; with light streaks before and behind this dark band about one scale wide 32.
With a dark band passing obliquely from behind the center of the eye to about the corner of the mouth; with light streaks before and behind this band about two scales wide 33.

32. General color usually brownish-green; Iowa to the Rockies
Crotalus viridis viridis Raf. Prairie Rattler
(*Crotalus confluentus confluentus* of Cope)
General color usually reddish-brown; Ariz. and Utah
Crotalus viridis nuntius (Klauber) Arizona Prairie Rattler

33. Ground color brown, with very dark dorsal blotches and a series of small dark blotches along each side, or sometimes almost completely dark; Idaho to Ariz. and westward
Crotalus viridis oreganus (Holbrook) Pacific Rattler
(*Crotalus confluentus lucifer* of Cope)
General color reddish or yellowish, with lateral blotches obscure or absent 34.

34. Adults reddish, with indistinct blotches; Grand Canyon, Ariz.
Crotalus viridis abyssus (Klauber) Grand Canyon Rattlesnake
Adults yellowish 35.

35. Adults pale yellowish, with obscure blotches; seldom over two feet long; Wyo. to Colo. and Utah
Crotalus viridis concolor (Woodbury) Faded Rattlesnake
(*Crotalus viridis decolor* (Gloyd))
Adults yellowish-brown, with more distinct blotches; getting to be over two feet long; Idaho to Ariz. and Cal.
Crotalus viridis lutosus (Klauber) Yellow Rattlesnake

36. With blotches anteriorly and with cross bands on back and sides along posterior two-thirds of body, or sometimes entirely dark 37.
Back usually with blotches along most of length; no cross bands 39.

37. Rostral plate as wide as or wider than high; snake grayish, with blotches on first third of body and narrow, regular bands posteriorly; tail

barred; Nevada, Ariz. and Cal.

Crotalus tigris Kennicott Tiger Rattlesnake

Rostral plate higher than wide; with large, irregular cross bands, or sometimes completely black; tail usually completely dark 38.

38. Usually with a brownish mid-dorsal stripe on the anterior part of the body; ground color pale; Texas to Ala., and northward to Ill.

Crotalus horridus atricaudatus (Latreille) Canebrake Rattler

Usually with a brownish mid-dorsal stripe on the posterior part of the body; ground color yellow to dark; Maine to Okla.

Crotalus horridus horridus Linn. Timber Rattlesnake, Black Rattlesnake

39. Supraocular pitted or ragged; Inyo Co., Cal.

Crotalus mitchellii stephensi Klauber Panamint Rattler

Not so 40.

40. With one row of small scales between the upper labials and the eye; usually with two or three rows of small, brownish blotches along the back; Ariz.

Crotalus triseriatus pricei (Van Denburgh) Price's Rattlesnake

With two or more rows of small scales between the upper labials and the eye; with a row of large blotches along the middle of the back 41.

41. With an upright light bar on each side of the front of the snout before the nostril; color greenish, with dark diamond-shaped blotches which have bright yellow borders; tail greenish above, ringed with black; N. C. to Fla. and Miss.

Crotalus adamanteus Beauvois Diamond-back Rattler

No such light bars; color grayish, pinkish or greenish, with diamond-shaped markings which have white or pale yellow borders; tail whitish, ringed with black 42.

42. Ground color greenish; light bands on tail wider than the dark bands; with a light line passing from the rear corner of the eye above the corner of the mouth; Utah to Texas and Cal.

Crotalus scutulatus (Kennicott) Mohave Rattlesnake
(*Crotalus scutellatus* (Kennicott))

Ground color grayish or reddish; light and dark bands on tail equal; with a light line passing from the rear corner of the eye to the mouth 43.

43. Ground color pinkish or yellowish, with dark dots; light bands on side of head parallel; Ark. to Texas and Cal.

Crotalus atrox (B. & G.) Western Diamond-back Rattler

Ground color reddish; light bands on side of head not quite parallel; Cal.

Crotalus ruber (Cope) Red Diamond-back Rattler

44. With two, large, lengthwise plates on the front area of the chin; pupil of eye round; with a black and brick-red pattern on the back, the red being in the form of squares or in cross bands; Family *Colubridae* (part) 45.

Front area of chin with small scales; pupil of eye vertical; back brownish or grayish; Family *Boidae* Boas 47.

45. Dark dorsal saddles usually with a straight edge or two points at each end (laterally); light interspaces about one-half depth (lengthwise) of dark saddles, white and almost clear; Ariz., Nev. and S. Cal.

Rhinocheilus lecontei clarus Klauber Banded Long-nosed Snake

Dark dorsal saddles coming to a single point at each end; light interspaces usually more than one-half depth of dark saddles, cream-colored, often red-tinted and usually much spotted laterally 46.

46. End of snout turned upwards, with the margin of the rostral plate raised above the surrounding scales; Kansas to Texas and N. M.

Rhinocheilus lecontei tesselatus Garman Spotted Long-nosed Snake

Margin of the rostral plate on the same plane as the surrounding scales; Idaho to Ariz. and Cal.

Rhinocheilus lecontei lecontei B. & G. LeConte's Long-nosed Snake

47. With a large plate on top of the head between the eyes; back grayish or brownish; belly clear yellow; Wash. and Mont. to Cal. and Utah

Charina bottae (Blainville) Rubber or Ball Snake

With many small scales on top of the head between the eyes; back grayish or brownish, often with three lengthwise stripes; belly reddish or yellowish, with brown markings 48.

48. Dorsal stripes zigzag and often obscure; Cal.

Lichanura roseofusca roseofusca (Cope) California Rosy Boa

Dorsal stripes almost straight, but with serrate margins, and usually quite distinct; Cal. and Ariz.

Lichanura roseofusca gracia Klauber Desert Rosy Boa

49. With a single large plate before and below the anus; Family *Colubridae* (part) 50.

With a divided large plate before and below the anus 118.

50. With a flat, triangular plate at the end of the snout, with prominent, projecting edges like a protecting shield; pupil of eye vertical; with a row of small scales between the eye and the upper labials 51.

Plate on end of snout normal; pupil of eye round, except in *Trimorphodon;* eye adjacent to one or more of the upper labials 55.

51. With less than 17 dark blotches along the middle of the back (not counting the tail) 52.

With more than 17 dark blotches along the middle of the back 53.

52. Dorsal blotches much nearer together than the depth (lengthwise) of the blotches; S. Ariz.

Phyllorhynchus browni browni Stejneger Brown's Leaf-nosed Snake

Dorsal blotches scarcely nearer together than the depth of the blotches; Maricopa Co., Ariz.

Phyllorhynchus browni lucidus Klauber Maricopa Leaf-nosed Snake

53. With 35 or more dark blotches along the middle of the back; around Tucson, Ariz.

Phyllorhynchus decurtatus nubilus Klauber
Cloudy Leaf-nosed Snake
With 34 or less dark blotches along the middle of the back 54.

54. Dorsal blotches about as far apart as the depth (lengthwise) of the blotches; Lower Cal. into Ariz.
Phyllorhynchus decurtatus decurtatus (Cope)
Peninsula Leaf-nosed Snake
Dorsal blotches farther apart than the depth of the blotches; S. Cal., Nev. and Ariz.
Phyllorhynchus decurtatus perkinsi Klauber
Perkins' Leaf-nosed Snake

55. Scales of back keeled 56.
Scales of back smooth (scales of tail smooth or keeled) 91.

56. With 25 or more rows of scales around the body anteriorly or in the middle (usually 29 to 35); usually light-colored, with dark blotches, above, or sometimes completely dark Bull Snakes 57.
With 23 or less rows of scales around the body (not counting the ventral plates); striped, with rows of small spots, or solid dark color above 66.

57. With two upper labial plates touching the eye on each side; normally with two prefrontal plates; a Mexican species which extends into S. Texas and Cal.
Pituophis deppei deppei (D. & B.) Mexican Bull Snake
(*Epiglottophis pleurostictus* of Cope)
With one or no upper labial touching the eye on each side; normally with four prefrontal plates 58.

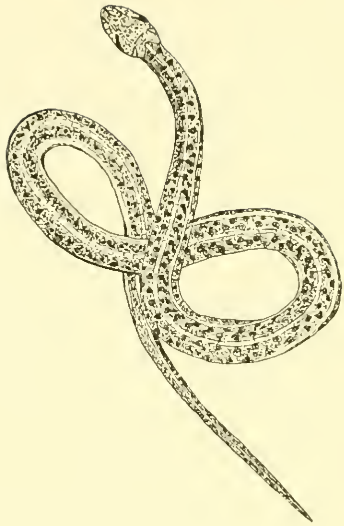
58. With less than 38 well separated dorsal blotches (on back and tail) or sometimes completely dark; width of rostrum about one-half height; head spotted, but without bands or stripes 59.
With more than 38 mid-dorsal blotches only three or four scales apart; width of rostrum more than one-half height; head with a band or bands 61.

59. Black above, gray below; adjoining sections of Ala. and Miss.
Pituophis melanoleucus lodingi Blanchard Black Pine Snake
Brownish or light above, with dark blotches 60.

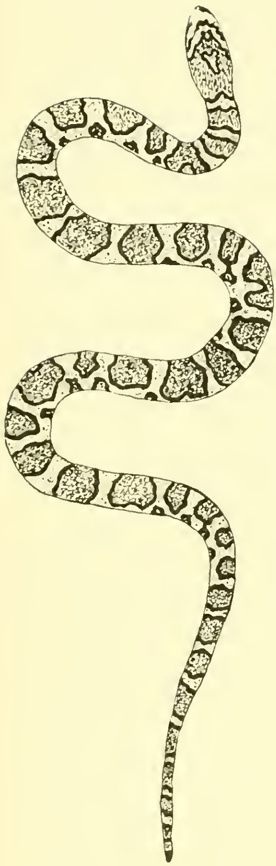
60. Brownish above, with obscure blotches; Fla.
Pituophis melanoleucus mugitus Barbour Florida Pine Snake
Whitish above, with distinct dark blotches; Tenn. to N. Y. and S. C.
Pituophis melanoleucus melanoleucus (Daudin) Common Pine Snake

61. Rostral plate noticeably narrower than high; yellowish, with dark blotches on the back, and a noticeable row of smaller dark spots along each side; Ind. to Cal. 62.
Rostral plate about as wide as high; yellowish, with dark blotches on the back; smaller dark spots along each side often obscure; Colo. westward 63.

62. Dorsal blotches squarish; Wis. and Ind. to the Rockies, and southward into Mexico



THAMNOPHIS SIRTALIS SIRTALIS



LAMPROPELTIS TRIANGULUM TRIANGULUM

AGKISTRODON MOKASEN

Pituophis sayi sayi (Schlegel) Common Bull Snake

Dorsal blotches incurved before and behind; Colo. to Cal. southwards
Pituophis sayi affinis Hallowell Arizona Bull Snake

63. Anterior mid-dorsal spots often incurved before and behind; central mid-dorsal spots reddish, posterior ones black; S. Cal.
Pituophis vertebralis (Blainville) Southern California Gopher Snake

Mid-dorsal spots oval or squarish and similarly colored 64.

64. Anterior mid-dorsal spots usually joining lateral spots and often joining each other; S. Cal.
Pituophis catenifer annectens (B. & G.) Checkered Gopher Snake

Anterior mid-dorsal spots scarcely joining lateral spots and never joining each other 65.

65. Light-colored scales on anterior part of body usually each with a central dark dot; Colo. to Wash. and Cal.
Pituophis catenifer deserticola Stejneger Desert Gopher Snake

Light-colored scales not dark dotted; Wash. to Cal.
Pituophis catenifer catenifer (Blainville) Pacific Gopher Snake

66. With one internasal plate; uniform dark brownish color above; belly yellowish or pinkish; Va. to Fla. and Texas
Haldea striatula (Linn.) Brown or Ground Snake
(*Potamophis striatulus* (Linn.))

With two internasals; usually with three lengthwise stripes or with several rows of spots; belly spotted or plain 67.

67. Nostril surrounded by a single plate (nasal) which is vertically grooved below the nostril; back usually striped; with two rows of dark spots close together along the middle of the belly; most of the central states to Texas
Tropidoclonion lineatum (Hallowell) Striped Swamp Snake

Nostril between two nasal plates; back striped or spotted; belly spots, if present, in two widely separated rows Garter Snakes 68.

68. With a pale stripe lengthwise along each side passing anteriorly through the third and fourth (and sometimes the second) rows of scales up from the ventral plates 69.

With a pale stripe passing anteriorly below the fourth row of scales (usually through the second and third) or sometimes absent 74.

69. Lateral stripe anteriorly on the third row of scales and one-half the second and fourth rows; upper labials six or seven; Ind. to N. Y. and Wis.
Thamnophis butleri (Cope) Butler's Garter Snake
(*Eutaenia butleri* Cope)

Lateral stripe anteriorly on the third and fourth rows of scales; upper labials on each side seven, eight or nine 70.

70. Tail about one-fourth or less total length; scales along the edge of the upper lip usually margined with dark or with dark coloring; belly often with dark markings 71.

Tail usually more than one-fourth total length; scales along the edge of the upper jaw usually pale; belly usually plain colored 72.

71. With 21 rows of scales anteriorly; with eight, sometimes nine, upper labials; stripes usually greenish; Texas to Cal.
Thamnophis macrostemma (Kennicott) Arizona Garter Snake
(*Thamnophis megalops* (Kennicott))
With 19 rows of scales anteriorly; with seven, sometimes eight, upper labials; stripes usually bright yellow or orange; Ill. and the Great Plains, northwestwards
Thamnophis radix (B. & G.) Plains Garter Snake

72. Usually with seven upper labials; with three bright yellow stripes on the body and usually with a streak of bright yellow before each eye; Maine to Mich., and southward to Ga.
Thamnophis sauritus sauritus (Linn.) Ribbon Snake
Usually with eight upper labials; with the dorsal stripe noticeably different from the laterals, either much deeper color or else very faint; without a yellow streak before each eye or with only a very dull one 73.

73. Dorsal stripe conspicuous and brighter than the laterals; Colo. and Neb. to Wis., and southwards (See note at end of chapter)
Thamnophis sauritus proximus (Say) Western Ribbon Snake
Dorsal stripe paler than the laterals, often absent except anteriorly; Fla. to Miss.
Thamnophis sauritus sackenii (Kennicott) Southern Ribbon Snake

74. With the lateral stripe passing anteriorly through the third row of scales only; with a bright yellow crescent on each side of the back of the head; Kansas to Cal.
Thamnophis marcianus (B. & G.) Marcy's Garter Snake
With the lateral stripe passing anteriorly through the second and third rows of scales, or sometimes absent; head color various 75.

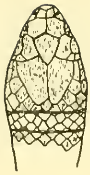
75. Greatest number of rows of scales on the body 21 or 23 (not counting the ventral plates) 76.
With nineteen or less rows of scales 83.

76. Most of the dorsal stripe present 77.
Most of the dorsal stripe absent 80.

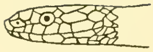
77. Belly brown; lateral stripes obscure; Cal.
Thamnophis ordinoides gigas Fitch Giant Garter Snake
Belly gray or marked with black; lateral stripes distinct 78.

78. Dorsal stripe with blurred or spotted edges; belly marked with black along the mid-ventral line; Mont. to Ariz., and westwards
Thamnophis ordinoides vagrans (B. & G.) Great Basin Garter Snake
Dorsal stripe with sharp edges; belly often clouded with black 79.

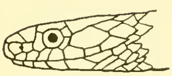
79. Belly pale, with few black markings; usually with one preocular plate on each side; southern Pacific States
Thamnophis ordinoides elegans (B. & G.) Pacific Garter Snake
(*Eutaenia elegans* (B. & G.))



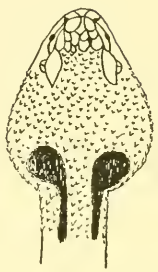
DIADOPHIS PUNCTATUS



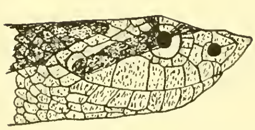
OPHEODRYS AESTIVUS



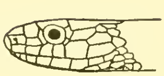
STORERIA DEKAYI



CROTALUS HORRIDUS



HETERODON CONTORTRIX



TROPIDOCLONION LINEATUM

Belly gray, with black clouding; preocular usually divided; Pacific States
Thamnophis ordinoides biscutatus (Cope) Klamath Garter Snake

80. Lateral stripes absent or very faint; with dark spots on the back, except in old specimens; Ariz. to Texas
Thamnophis angustirostris (Kennicott) Spotted Garter Snake
Lateral stripes distinct; usually with alternating rows of dark spots 81.

81. Preocular usually single; lateral stripes mostly gray; Oregon
Thamnophis ordinoides hydrophila Fitch Oregon Garter Snake
Preocular usually divided; lateral stripes yellow 82.

82. Usually with ten lower labials; belly usually mostly pale; Cal.
Thamnophis ordinoides hammondii (Kennicott) California Garter Snake
Usually with eleven lower labials; belly often with black markings; Cal. into Nevada
Thamnophis ordinoides couchii (Kennicott) Sierra Nevada Garter Snake

83. Eye distinctly small; pairs of plates beneath chin about the same size; scale rows often 17; lower labials usually eight or nine; dorsal stripe sometimes red; West Coast
Thamnophis ordinoides ordinoides (B. & G.) Western Garter Snake
Length of eye about equal to the distance from eye to nostril; second pair of plates beneath chin longer than the first pair; scale rows usually 19; lower labials usually nine or ten 84.

84. Upper labials usually eight 85.
Upper labials usually seven 86.

85. Head as wide as the width through the thickest part of the body; dorsal stripe on only one row of scales for most of length; with a yellow crescent on each side of head behind corner of mouth; color brownish, red tinted; Utah to Ariz. and Texas
Thamnophis eques eques (Reuss) Brown Garter Snake
Head narrower; dorsal stripe wider; often with red in the coloration; Cal. coast
Thamnophis ordinoides atratus (Kennicott) Coastal Garter Snake

86. With whitish or bluish spaces (on the skin, not the scales) between the dark dorsal spots; no red color (See note at end of Chapter.) 87.
With reddish spaces between the dark dorsal spots 88.

87. Dorsal and lateral stripes narrow and irregular, and bluish-green in color; Puget Sound area, Wash.
Thamnophis sirtalis pickeringii (B. & G.) Puget Sound Garter Snake
Dorsal and lateral stripes broad and regular, and orange-yellow in color; Minn. southward and eastward
Thamnophis sirtalis sirtalis (Linn.) Eastern Garter Snake

88. Dorsal stripe covering only a single row of scales; lateral stripes broken or absent; Wash. and Oregon

Thamnophis sirtalis concinnus (Hallowell) One-striped, Red-barred Garter Snake

Dorsal stripe covering more than a single row of scales; lateral stripes entire 89.

89. Great Plains area

Thamnophis sirtalis parietalis (Say) Great Plains Red-barred Garter Snake

Pacific States 90.

90. Color between the light stripes usually in stripes only; Wash. to Cal.

Thamnophis sirtalis tetrataenia (Cope) Cascade Red-barred Garter Snake

With a spotted appearance between the light stripes; Oregon, Nevada and Cal.

Thamnophis sirtalis infernalis (Blainville) California Red-barred Garter Snake

91. No loreal; prefrontal and parietal plates each touching one upper labial; ground color above grayish, red-mottled, with dark brown blotches; belly dark-mottled; Fla.

Stilosoma extenuatum Brown Short-tailed Snake
(*Stylophis extenuatus* (Brown))

With one or more loreals on each side; with the prefrontals or the parietals or both not touching any upper labials; color various 92.

92. Pupil of eye vertical; usually with two or three loreals on each side; back teeth grooved (semi-poisonous); with a row of dark blotches along the back, each usually with a central, transverse, light area; scale count 21 to 24; Cal.

Trimorphodon vandenburghi Klauber California Lyre Snake

Not so; pupil of eye round; usually with one loreal on each side; back teeth not grooved 93.

93. With 15 to 17 rows of scales around the body (not counting the ventral plates) 94.

With 19 or more rows of scales around the body 95.

94. With 17 rows of scales around the body; frontal plate about as wide as long; color above and below almost uniformly brown or black (the body may be darker posteriorly, or the scales may be dark with reddish color at their bases or tips); chin reddish; S. C. to Fla. and Texas

Drymarchon corais couperi (Holbrook) Indigo Snake

With 15 to 17 rows of scales; frontal plate distinctly longer than wide; color plain, striped or banded (Snakes normally having a divided anal plate, but occasionally having a single one.) Whip Snakes and Racers 208.

95. Belly plain white or yellow; rostral plate projecting part way between the internasals, when viewed from above 96.

Belly with some dark markings; rostral plate not projecting between the internasals, when viewed from above King Snakes 98.

96. With 19 rows of scales; with wide, black-edged, red blotches along the back, separated by half-rings of white or yellow; N. J. to Fla. and Okla.

Cemophora coccinea (Blumenbach) Scarlet or False Coral Snake

With 27 to 31 rows of scales; back brownish, with dark brown blotches; with smaller brown blotches along the sides 97.

97. Dorsal blotches shorter than spaces between them, covering lengthwise only one and one-half to two rows of scales; Utah to Ariz. and Cal.

Arizona elegans occidentalis Blanchard Western Smooth-scaled Coluber

Dorsal blotches longer than spaces between them, covering lengthwise two to three scale rows; Kansas to Ariz. and Texas

Arizona elegans elegans (Kennicott) Texas Smooth-scaled Coluber

(*Rhinechis elegans* of Cope)

98. Back gray, with narrow, dark cross bands, half of which are usually mixed with red; belly usually mostly dark; Texas (Davis Mts.)

Lampropeltis alterna (Brown) Davis Mountain King Snake

(*Ophibolus alternus* Brown)

Not so 99.

99. With two colors in the back pattern, either with pale-centered scales, or with pale rings, bands or stripes on a darker background; no red in the color pattern 100.

With three colors in the back pattern; either with red, black and light bands, or with reddish or brownish, black-margined blotches on a pale background; with or without red in the color pattern 108.

100. With a light mid-dorsal stripe; Oregon to Ariz. and Cal.

Lampropeltis getulus californiae (Blainville) California King Snake

Not so 101.

101. Most of the dorsal scales evenly spotted 102.

With cross bands or with some of the light spots arranged in cross bands 103.

102. With a vivid light spot in the middle of each scale; Neb. to Ala. and Texas

Lampropeltis getulus holbrooki (Stejneger) Spotted King Snake

(*Ophibolus getulus sayi of Cope*)

With light shading at the base of each scale; Fla.

Lampropeltis getulus brooksi Barbour Brown King Snake

103. With most of the scales of the back between the cross bands light-spotted 104.

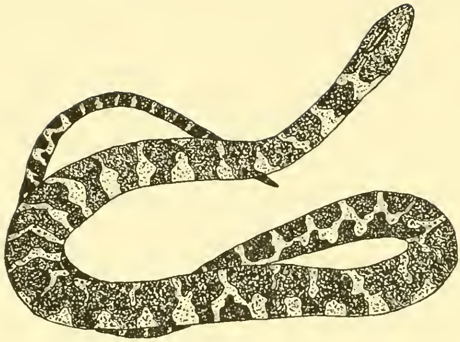
With few or no light-spotted scales on the back between the cross bands; sides may be spotted 105.

104. With indistinct, light cross bands on a greenish background; Fla.

Lampropeltis getulus floridana Blanchard Florida King Snake

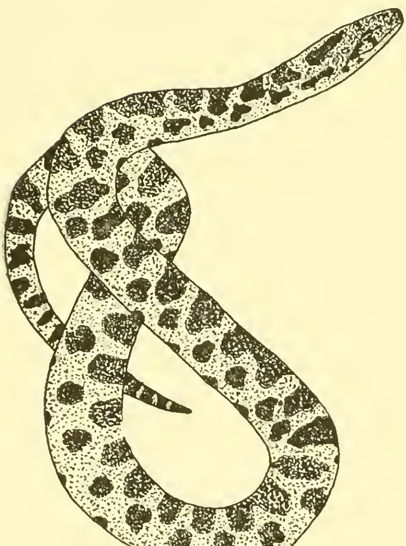
With distinct, light cross bands on a brown or black background; N. J. to Fla. and Ala.

Lampropeltis getulus getulus (Linn.) Common King Snake, Thunder or Chain Snake



NATRIX SIPEDON

SIPEDON



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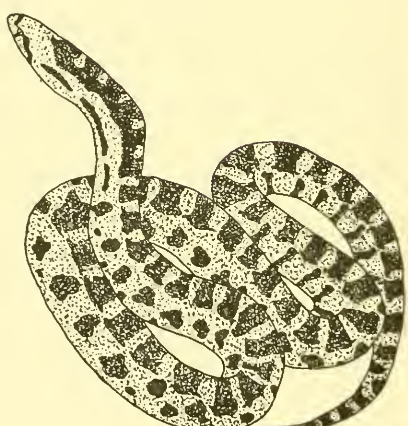

PITUOPHIS SAYI

105. With well defined, light cross bands only 106.
With light-spotted scales forming cross bands which may fork and unite on the sides in a chain-like fashion, or form a diffuse, spotted pattern along each side 107.

106. Light-colored scales with brown shading at their bases; white bars on prefrontals straight edged behind; Ariz. and Cal.
Lampropeltis getulus yumensis Blanchard Yuma King Snake
Light-colored scales without brown shading at their bases; white bars on prefrontals curved outwards behind; Oregon to Ariz and Cal.
Lampropeltis getulus boylii (B. & G.) Boyle's King Snake

107. With 23 to 25 rows of scales around the body; belly mostly dark; with a vivid light spot in the center of each scale on the sides between the cross bands; in states bordering Mexico
Lampropeltis getulus splendida (B. & G.) Splendid King Snake
With 21 rows of scales around the body; belly yellow, with dark blotches; sides obscurely or not spotted, except on the cross bands; Ind. to Ala.
Lampropeltis getulus niger (Yarrow) Frosted King Snake

108. Coloring with red, black and pale cross bands, with the black or pale bands extending well on to the ventral plates, usually forming rings around the body (See note at end of chapter.) 109.
Back with reddish or brownish, black-bordered blotches on a pale background; black and pale bands not continuously extending much on to the ventral plates 114.

109. With reddish rings around the body about four times the width of the spaces between, which are black, with a very faint, central ring of yellow; Texas
Lampropeltis triangulum annulata (Kennicott) Mexican King Snake
(*Osceola doliata annulatum* (Kennicott))
(*Ophibolus micropholis* (Cope) (part))
Reddish rings shorter; pale rings almost as wide as, or wider than, the dark ones 110.

110. With a pale band across the top of the back of the head, extending down on the sides directly before the angle of the jaws 111.
With a pale band across the neck, extending down on the sides directly behind or just involving the angle of the jaws 112.

111. Snout white; Nev. to N. M.
Lampropeltis pyromelana (Cope) Arizona Ringed King Snake
(*Ophibolus zonatus* (Blainville))
Snout black; Wash. to Cal.
Lampropeltis multicincta (Yarrow) California Ringed King Snake
(*Ophibolus zonatus* (Blainville))

112. Greatest number of rows of scales around the body 19; loreal absent or almost so; southeastern states

Lampropeltis triangulum elapsoides (Holbrook) Southern King Snake

(*Osceola elapsoidea of* Cope)

Greatest number of scale rows 21 or more; one or more normal loreals present on each side 113.

113. Red not continuous on the belly; black bands usually spreading into the yellow ones on the mid-line of the belly; yellow bands above usually wider than the black ones; S. D. to Ariz. and Texas

Lampropeltis triangulum gentilis (B. & G.) Western King Snake

(*Ophibolus doliata gentilis* (B. & G.))

With red rings around belly; yellow and black bands about the same width above; lower Mississippi Valley, Okla. and Texas

Lampropeltis triangulum amaura (Cope)) Scarlet King Snake

(*Ophibolus doliata coccineus* (Schlegel))

114. Back with narrow cross blotches barely or not reaching the fifth row of scales on each side up from the ventral plates 115.

Back with wide blotches in broad contact with a fifth or lower row of scales 116.

115. With 23 or less rows of scales around the body; head markings are a dark streak on each side from behind the eye to the angle of the jaw; dark blotches on the back obscure and wider in the middle; with smaller obscure blotches on the sides; Maryland to Fla. and Ala.

Lampropeltis rhombomaculata (Holbrook) Mole King Snake

With 25 or more rows of scales around the body; head with a dark band across the front, a dark patch in the center, and a dark streak on each side from behind the eye to the angle of the jaw; dark blotches on the back distinct and wider at the sides; with smaller blotches on the sides; Wis. to Kentucky, Miss. and Texas

Lampropeltis calligaster (Harlan) Yellow-bellied King Snake

116. With small, dark, alternate blotches (below the large, central blotches) on the scales above the ventral plates, sometimes with another row along each side of the ventral plates; Iowa eastward and northward, and southward in the Appalachians

Lampropeltis triangulum triangulum (Lacépède) Checkered Adder, Milk or House Snake

(*Ophibolus doliata triangulum* (Lacépède))

With small, dark, alternate blotches (below the large central blotches) along each side of the ventral plates 117.

117. With the large central blotches reaching down on each side almost to the ventral plates; Minn. to Okla. and Tenn.

Lampropeltis triangulum syspila (Cope) Western Milk Snake

(*Ophibolus doliata syspila* (Cope))

With the large, central blotches reaching down on each side on to the sides of the ventral plates; N. J. to Maryland and Del.

Lampropeltis triangulum temporalis (Cope) Southern Milk Snake

118. With red, black and yellow rings completely encircling the body, the yellow being adjacent to the red; with rigid poison fangs in the front

of the upper jaw; Family *Elapidae* Coral Snakes 119.
Color not so; no poison fangs so situated; non-poisonous and semi-poisonous snakes; Family *Colubridae* (part) 122.

119. With a yellow cross band on the head, followed by a red ring; yellow rings on body three or more scales wide; N. M., Ariz. and S. Idaho
Micruroides euryxanthus (Kennicott) Sonora Coral Snake
With a yellow cross band on the head and a black ring behind it; yellow rings on body one or two scales wide 120.

120. Red areas relatively clear; S. Florida
Micrurus fulvius barbouri Schmidt Florida Coral Snake
Red areas dark spotted 121.

121. Red areas irregularly dark spotted; Miss. to Texas
Micrurus fulvius tenere (B. & G.) Southern Coral Snake
Usually with two dark areas or spots on each red band; Ind. to the Gulf, and eastward in the coastal states to N. C. and Fla.
Micrurus fulvius fulvius (Linn.) Common Coral Snake
(*Elaps fulvius* (Linn.))

122. Snout very long and slender, with distance from eye to end of snout about four times as long as the eye; tail more than one-third total length; with poison fangs in the back part of the upper jaw; color reddish; belly white striped; Ariz.
Oxybelis microphthalmus B. & A. Arizona Vine Snake
Not so 123.

123. With some or all of the scales of the back keeled 124.
Scales of back smooth (scales of tail smooth or keeled) 152.

124. Rostral plate with a ridge above and turned up at the end Hog-nosed Snakes, Puffing Adders, Sand Vipers or Flat-nosed Adders 125.
Rostral plate not so 129.

125. Prefrontals adjacent; light areas usually dark dotted 126.
With small scales between the prefrontals; light areas clear 127.

126. Usually no small scale behind the rostrum, separating the internasals; mid-dorsal dark blotches less than 20; Fla. (See note at end of chapter.)
Heterodon contortrix browni (Stejneger) Florida Hog-nosed Snake
With a small scale (azygous) behind the rostrum, separating the internasals; mid-dorsal dark blotches often more than 20, or sometimes the back is entirely dark; N. H. to Minn., and southward
Heterodon contortrix contortrix (Linn.) Puffing or Spreading Adder, Common Hog-nosed Snake
(*Heterodon platyrhinos* of Cope)

127. Middle of belly light; Ind. to N. C. and Fla.
Heterodon simus (Linn.) Southern Hog-nosed Snake
With a black area lengthwise along the middle of the belly 128.

128. With six or less small scales around the azygous (small scale behind rostrum); belly mostly dark; southward from Ariz. to Texas

Heterodon nasicus kennerlyi (Kennicott) Southwestern Hog-nosed Snake
With eight small scales around the azygous; belly dark along mid-line; Ill. to Mont. and southwards
Heterodon nasicus nasicus (B. & G.) Western Hog-nosed Snake

129. With 15 to 17 rows of scales around the anterior or middle of the body (not counting the ventral plates) 130.
With 19 or more rows of scales around the body 135.

130. With one internasal or with no preocular (prefrontals touching eyes) or both 131.
With two internasals; with one or more preoculars; prefrontals not reaching eyes 132.

131. Usually with six upper labials; with two internasals; smooth anteriorly, but with the scales near the tail keeled; brown above, usually with two rows of small dark dots; belly yellowish; Ind. to Texas
Haldea valeriae elegans (Kennicott) Western Ground Snake
(*Virginia elegans* Kennicott)
Usually with five upper labials; usually with one internasal; scales of back keeled; brown above; yellow below; Va. to Fla. and Texas
Haldea striatula (Linn.) Southern Ground Snake
(*Potamophis striatulus* (Linn.))

132. Back and sides dark, with a faint lengthwise streak in the center of some of the scales, so that they appear to be keeled; belly red, with black cross bars; some of the scales of the tail faintly keeled; N. C. to Fla.
Seminatrix pygaea (Cope) Mud or Black Swamp Snake
Scales of back keeled; color above brown or green; belly usually plain colored 133.

133. With a loreal plate; nostril situated in the middle of a single nasal plate; back green; belly yellowish; Conn. to N. M.
Opheodrys aestivus (Linn.) Rough Green Snake
No loreal; nostril between two nasal plates; back brown; belly red or pink 134.

134. With 15 rows of scales around the body; belly red; with the dark color of the back extending on to the sides of the ventral plates; eastern and central states
Storeria occipitomaculata (Storer) Red-bellied Brown Snake
With 17 rows of scales; belly pinkish; eastern and central states
Storeria dekayi (Holbrook) De Kay's Little Brown Snake

135. With less than 180 transverse plates on the belly before the anus; scales strongly keeled Water Snakes 136.
With more than 185 ventral plates; scales weakly keeled; abdomen flattened, forming an angle with the sides
Rat Snakes, Chicken Snakes or Colubers 156.

136. Normally with 19 rows of scales around the body 137.
Normally with 21 to 33 rows of scales 140.

137. Back brown, with darker spots and blotches; belly red, with a row of dark spots on each side; with seven lower labials; Wis. to Kentucky

Natrix kirtlandii (Kennicott) Kirtland's Water Snake
(*Regina kirtlandii* Kennicott)

Back lengthwise striped or almost plain; belly yellow, with or without dark stripes or spots; with nine or more lower labials 138.

138. Belly yellow, with two rows of dark spots which sometimes fuse to form two stripes with irregular sides; back brown, with two dark stripes; sides pale but unstriped; S. C. to La.

Natrix rigida (Say) Striped Water Snake

Belly yellow or with dark stripes; back with or without dark stripes; with a pale stripe along each side (faint in adults) 139.

139. Stripe along each side narrow, involving part of the first and second rows of scales; with two to four dark stripes on the belly; Wis. to Pa., and southwards

Natrix septemvittata (Say) Queen or Moon Snake

Stripe along each side wider, involving the first three rows of scales; belly plain yellow or with a central dark stripe; Ill. to La. and Texas

Natrix grahamii (B. & G.) Graham's Water Snake

140. Usually with 21 to 25 rows of scales around the body (*N. erythrogaster transversa* sometimes with 27); usually with ten lower labials 141.

Usually with 27 to 33 rows of scales (*N. rhombifera rhombifera* sometimes with 25); usually with eleven or more lower labials 149.

141. Belly almost plain yellowish or reddish, sometimes with dark shading on the front edges of the ventral plates 142.

Belly usually with definite light or dark markings 143.

142. Plain colored in the adult; Texas to Ohio and Wis.

Natrix erythrogaster erythrogaster (Forster) Red-bellied Water Snake

With dark blotches on the back alternating for the entire length with the dark blotches of the sides; Mo. to Okla.

Natrix erythrogaster transversa (Hallowell) Blotched Water Snake

143. With a row of light spots along the middle of the belly 144.

Belly with dark markings and without a central row of light spots 145.

144. Back obscurely banded; Fla.

Natrix compressicauda (Kennicott) Salt-water Moccasin, Flat-tailed Water Snake

Back with four dark stripes; Texas to Fla.

Natrix clarkii (B. & G.) Clark's Water Snake

145. With 18 or less dark markings along the middle of the back; belly whitish, with squarish dark spots; Kansas to Texas and La.

Natrix sipedon confluens (Blanchard) Yellow Water Snake

With 19 or more dark markings along the middle of the back 146.

146. Usually with cross bands along the entire length of the back; with a distinct light line from the eye to the angle of the jaw 147.

With dark bands across the anterior part of the back and with alternating dorsal and lateral blotches posteriorly; light line from eye to angle of jaw less distinct or absent 148.

147. With about 24 cross blotches on the back; usually with small side blotches; Neb. to Fla.

Natrix sipedon fasciata (Linn.) Southern Banded Water Snake (*Tropidonotus fasciata fasciata* (Linn.))

With about 29 cross blotches on the back; sides without small alternating blotches; Fla.

Natrix sipedon pictiventris (Cope) Florida Banded Water Snake

148. Dorsal blotches or bands larger than the spaces between; belly with irregularly placed color markings; Maine to Okla.

Natrix sipedon sipedon (Linn.) Common Banded Water Snake

Dorsal blotches or bands about equal to the spaces between; belly with color markings arranged in two lengthwise rows; Ind. to S. C. and Ark.

Natrix sipedon pleuralis (Cope) Cope's Water Snake

149 Parietals each about the size of the frontal plate; parietals not joining along the mid-line; with dark alternating spots and blotches on the back and sides; Va. to Fla. and La.

Natrix taxispilota (Holbrook) Water Pilot

Parietals each considerably larger than the frontal, and joining on the mid-line; usually with dark spots or bands, which are sometimes faint or absent 150.

150. Eye in contact with one of the upper labials; back and side dark color markings joining, forming a diamond pattern (often very faint); Ind. to Texas

Natrix rhombifera rhombifera (Hallowell) Diamond-back Water Snake

With small scales between the eye and the upper labials; back and sides with alternating dark cross bands 151.

151. Belly mostly pale; S. C. to Fla.

Natrix cyclopion floridana Goff Florida Green Water Snake

Belly brown posteriorly, with small, light markings; Ind. to La. and Ala.

Natrix cyclopion cyclopion (D. & B.) Louisiana Green Water Snake

152. With 21 or more (very rarely 20) rows of scales around the anterior or middle of the body (not counting the ventral plates) 153.

With 19 or less rows of scales around the body 166.

153. Pupil vertical; with 21 (rarely 20) to 23 rows of scales around the body; scales smooth 154.

Pupil of eye round; with 25 to 35 rows of scales around the body; scales smooth or faintly keeled; belly flattened, forming an angle with the sides Rat Snakes, Chicken Snakes or Colubers 156.

154. With a row of brown blotches on the back, each usually with a transverse, light, central area; usually with smaller blotches on the sides; with nine upper labials; usually with two loreals, one above the other, on each side of the head; back teeth in upper jaw grooved; semi-poisonous; Utah, Ariz. and Cal.

Trimorphodon lyrophanes (Cope) Jew's-harp or Lyre Snake

With a row of dark blotches on the back; with or without blotches on the sides; with eight upper labials (on each side); with one loreal; back teeth grooved or not 155.

155. With dark blotches along the back and with one or two rows of alternating dark blotches on the sides; back teeth in the upper jaw large but not grooved; Wash. to Cal., Kansas and Texas

Hypsiglena ochrorhyncha Cope Rock Snake

With dark cross bands across back and sides; back teeth in the upper jaw grooved; Texas

Leptodeira septentrionalis septentrionalis (Kennicott)
(*Sibon septentrionale of* Cope)

156. With small scales between the eye and the upper labials; back usually with dark blotches; Texas

Elaphe sclerotica H. M. Smith Davis Mountain Coluber
(*Coluber subocularis* Brown)

Eye in contact with one or more of the upper labials; back with or without dark blotches 157.

157. Usually with nine upper labials; young with more than 50 dark blotches on the back; adults dark, with obscure, light, lengthwise stripes; Texas

Elaphe bairdi (Yarrow) Baird's Coluber

Usually with eight upper labials; mid-dorsal, dark blotches, if present, often fewer 158.

158. Scales smooth or with five or less rows of faintly keeled scales along the middle of the back; with two dark bands extending from the neck on to the top of the head, passing across the parietal plates and joining on the frontal 159.

With nine or more rows of faintly keeled scales along the middle of the back; no dark bands so situated on head 162.

159. With dark brown blotches on a brownish or grayish background; with a row of three temporals on each side of head directly behind the postoculars; Neb. southwards 160.

With dark bordered, reddish blotches on a pinkish tinted background; with a row of two temporals on each side of head directly behind the postoculars; southeastern states 161.

160. Belly so closely spotted that there are seldom any ventral plates without spots; Colorado R. basin

Elaphe laeta intermontanus Woodbury, A. M. & M. W. Colorado River Smooth Coluber

Belly less closely spotted, so that there are several to many ventral plates without spots; from Neb. southwards

Elaphe laeta laeta (B. & G.) Western Smooth Coluber

161. Frontal plate about as wide as long; dark markings on top of head rather obscure; belly pinkish, with obscure markings; S. Florida

Elaphe rosacea (Cope) Rosy Rat Snake

Frontal plate longer than wide; with red, black bordered, markings on head; belly yellowish, with dark markings; N. J. to Fla. and La.

Elaphe guttata (Linn.) Corn or Red Chicken Snake, Scarlet Racer
(*Coluber guttatus* Linn.)

162. Parietals shorter than the distance from the front of the frontal plate to the end of the snout; back with brown blotches on a lighter ground; sides with small alternating blotches; belly yellow, with dark spots; with less than 220 ventral plates 163.

Parietal plates about as long as, or longer than, the distance from the front of the frontal plate to the end of the snout; back striped, blotched or plain; with more than 220 ventral plates 164.

163. With about 40 (over 33) dark, mid-dorsal blotches three or four scales in length; S. D. to Ind.

Elaphe vulpina vulpina (B. & G.) Western Fox Snake

Mid-dorsal blotches fewer (less than 39) and longer (four to six scales long); Mich. and along the Lake Shores into N. Y. state

Elaphe vulpina gloydi Conant Eastern Fox Snake

164. Back with four dark, lengthwise stripes in the adult; with or without dark blotches on the back; belly plain yellow or with obscure dark markings; N. C. to Fla. and La.

Elaphe quadrivittata (Holbrook) Striped Yellow Rat Snake

Back without stripes; with or without dark blotches; belly usually with distinct dark markings 165.

165. With dark brown blotches on the back, those toward the neck H-shaped; with one or two rows of smaller blotches along each side; head dark spotted, usually with a dark band on each side from behind the eye to the corner of the mouth; southeastern and south-central states

Elaphe obsoleta confinis (B. & G.) Gray Rat or Spotted Chicken Snake

Blotches obscure or absent, except in the young; back almost uniformly dark in the adult; scales dark, often pale-edged, and with white or red skin between the scales, giving the appearance of blotches; usually with uniform coloring on top of the head; Wis. to Texas, and eastwards

Elaphe obsoleta obsoleta (Say) Pilot Black Snake

166. With 13 rows of scales around the body 167.

With 15 to 19 rows of scales around the body 172.

167. With five upper labials on each side; back uniformly brown or black 168.

With seven upper labials on each side; back with cross bands or with a dark streak or spot on each scale 170.

168. Back purplish-black; belly pinkish, with this color reaching up on each side to the third row of scales; Neb. to La. and Texas

Carphophis amoena vermis (Kennicott) Black Worm Snake

Back brown; belly salmon, with this color not reaching up to the third row of scales on each side 169.

169. Internasals often single, reduced or absent; Ohio to Miss.

Carphophis amoena helenae (Kennicott) Helen's Worm Snake

With two internasals; eastern coastal states

Carphophis amoena amoena (Say) Brown Worm Snake

170. Ventral plates before the anus 125 or more; rostral plate slightly separating the internasals; loreal present; brown above, with a dark streak along the center of each scale; belly white; Texas

Sonora taylori (Boulenger) Taylor's Snake

(*Contia taylori* Boulenger)

Ventral plates before the anus less than 123; rostral plate almost or entirely separating the internasals, which are each joined with an anterior nasal; no loreal; color either in cross bands or back brown, with a dark dot at the posterior margin of each scale 171.

171. Rostral plate not entirely separating the internasals; color above brown, with a dark dot at the rear margin of each scale; Lower Cal.

Chilomeniscus stramineus Cope Dark Ground Snake

Rostral plate entirely separating the internasals; color above reddish, with dark cross bands; Ariz. and Cal.

Chilomeniscus cinctus Cope Red-and-black Ground Snake

172. Normally with 15 to 17 rows of scales around the body 173.
Normally with 19 rows of scales around the body 220.

173. Rostral plate abnormal (see below) 174.
Rostral plate normal 175.

174. Rostral plate turned up at the end and entirely separating the internasals above; back orange, with darker blotches or cross bands; belly yellowish; Ariz. to Texas

Ficimia cana (Cope) Dog-nosed Snake

Rostral plate flattened in front and partly free at the sides; internasals partly in contact; back with a central yellow stripe, bordered on each side by a dark stripe or a row of dark spots; belly yellowish; Utah to Texas and Cal.

Salvadora grahamiae B. & G. Patch-nose Snake

175. No loreal; prefrontals projecting between the nasals and the preocular, reaching nearly or quite to the upper labials; color on back uniformly brown; head darker; with or without a yellow ring or band at the back of the head; semi-poisonous snakes with grooved poison fangs in the back of the upper jaw 176.

Loreal usually present; each prefrontal separated from the upper labials by a scale squarely adjacent to its lower margin; color various 182.

176. No light band across the back of the head 177.
Usually with a light band across the back of the head 179.

177. Usually with six upper labials; head not much darker than the body; Mo. to Texas

Tantilla gracilis B. & G. Slender Black-headed Snake

Usually with seven upper labials; head very dark 178.

178. With less than 142 ventral plates; Okla. to Texas

Tantilla kirnia Blanchard Oklahoma Black-headed Snake

With more than 144 ventral plates; Colo. to Texas and Ariz.

Tantilla nigriceps Kennicott Western Black-headed Snake

179. With the light band passing across the posterior ends of the parietals 180.
With the light band passing across the middle of the parietals 181.

180. Dark band on neck (behind the light band) not more than one and one-half scales wide; Ariz.
Tantilla wilcoxi Stejneger Wilcox's Black-headed Snake
Dark band on neck two to four scales wide; Va. southwards
Tantilla coronata B. & G. Crowned Snake

181. Dark color of head spreading on to the throat; Cal.
Tantilla eiseni Stejneger Ringed Black-headed Snake
Dark color of head not spreading below the mouth; Okla. to Texas and Ariz.
Tantilla atriceps (Günther) Light-chinned Black-headed Snake

182. No preocular plates; prefrontal plates bordering eyes; back brown, with or without two rows of small dark dots; belly yellow 183.
With one or more preoculars; prefrontals not bordering eyes; color various 184.

183. With 15 rows of scales; N. J. to Ohio, southward to S. C.
Haldea valeriae valeriae (B. & G.) Eastern Ground Snake
With 17 rows of scales; Ind. to Texas
Haldea valeriae elegans (Kennicott) Western Ground Snake

184. Nostril situated in an ungrooved, single nasal plate 185.
Nostril between two plates or in one plate which is vertically grooved below the nostril 193.

185. Back grass green; belly whitish; with more than 66 pairs of plates beneath the tail; N. D. to N. M. and eastward
Opheodrys vernalis (Harlan) Smooth Green or Grass Snake
(*Liopeltis vernalis* (Harlan))
Color not so; with less than 62 subcaudals 186.

186. Color reddish-brown above, usually with a faint lengthwise stripe along the fourth or fifth row of scales up on each side; plates of belly yellowish, with dark front borders; West Coast
Contia tenuis (B. & G.) Pacific Ground Snake
Back color various; belly plain light colored or with dark cross bars which form rings around the body 187.

187. Snout much flattened and extending well beyond lower jaw; sides of belly angled; with dark cross bands; Nev., Ariz., and Cal.
Sonora occipitalis (Hallowell) Ringed Ground Snake
Snout and belly normally curved 188.

188. Ventral plates usually less than 154 in males, 166 in females; with or without dark cross bands 189.
Ventral plates usually more than 154 in males, 162 in females; with or without dark cross bands 190.

189. Males with 52 or less pairs of subcaudal plates, females with less than 45; Kansas, Colo. and southwards
Sonora episcopa (Kennicott) Brown Ground Snake
Males with 53 or more pairs of subcaudal plates, females with more than 45; southwestern Texas
Sonora semiannulata blanchardi Stickel Blanchard's Ground Snake

190. No cross bands; mid-dorsal area reddish 191.
With cross bands 192.

191. With a distinct, red, mid-dorsal stripe; Cal.
Sonora miniata linearis Stickel Red-striped Ground Snake
Mid-dorsal stripe obscure; Idaho and Ariz.
Sonora miniata miniata Stickel Red Ground Snake

192. With most of the cross bands forming rings around the body; Grand Canyon, Ariz.
Sonora semiannulata gloydi Stickel Gloyd's Banded Ground Snake
With cross bands only; Idaho southwards
Sonora semiannulata semiannulata (B. & G.) Western Banded Ground Snake

193. With less than 135 ventral plates (before anus) 194.
With more than 139 ventral plates 195.

194. With less than 60 pairs of subcaudal plates; back black, with a pale streak along the center of some of the scales; belly red, with black cross bars; N. C. to Fla.
Seminatrix pygaea (Cope) Mud or Black Swamp Snake
With more than 60 subcaudals; reddish-brown above; clear yellow below; upper lips yellow; N. C. to Fla. and Texas
Rhadinaea flavilata (Cope) Yellow-lipped Snake

195. With less than 70 pairs of subcaudal plates; frontal plate not much longer than wide 196.
Usually with more than 70 pairs of subcaudals; frontal plate distinctly longer than wide Whip Snakes and Racers 208.

196. Reddish-brown above, usually with a faint lengthwise stripe along the fourth or fifth row of scales up on each side; plates of belly yellowish, with dark front borders; West Coast
Contia tenuis (B. & G.) Pacific Ground Snake
Dark colored above, with or without a yellow ring around the neck; belly plain yellowish or with dark spots Ring-necked Snakes 197.

197. Dark color of back not covering anteriorly the first row of scales up on each side 198.
Dark color of back covering anteriorly the first row of scales up on each side 201.

198. Chin unspotted; belly mostly without spots; Minn. to the Carolinas
Diadophis punctatus edwardsii (Merrem) Edwards' Ring-necked Snake
Chin and belly spotted 199.

199. Spots on belly usually scattered; Minn. to Ind. and Texas
Diadophis punctatus arnyi (Kennicott) Central Ring-neck Snake
Spots on belly usually concentrated along the mid-ventral line 200.

200. Spots on belly in a single row of large, dark semi-circles; southeastern states to Maryland

Diadophis punctatus punctatus (Linn.) Southeastern Ring-necked Snake

Spots on belly rather small, less regular, and often in more than one row along the mid-ventral line; Ill. southward

Diadophis punctatus stictogenys Cope Mississippi Valley Ring-necked Snake

201. Males usually with more than 205 ventrals, females with more than 218 ventrals 202.

Males usually with less than 205 ventrals, females with less than 218 ventrals 203

202. Light ring on neck obscure or absent; Idaho to Ariz. and Texas

Diadophis regalis regalis (B. & G.) Regal Ring-necked Snake

Light ring on neck usually rather wide; Ariz.

Diadophis regalis laetus (Jan.) Arizona Ring-necked Snake (*Diadophis regalis arizonae* Blanchard)

203. Dark color of back usually completely covering all but the first row of scales up on each side 204.

Dark color of back usually not completely covering all but the first row of scales up on each side 205.

204. With 17 rows of scales anteriorly; Cal.

Diadophis amabilis modestus (Bocourt) Los Angeles Ring-necked Snake

With not more than 15 rows of scales around body; S. Cal.

Diadophis amabilis similis Blanchard San Diego Ring-necked Snake

205. First row of scales on each side without dark markings; Cal. and S. Oregon

Diadophis amabilis pulchellus (B. & G.) Eldorado Ring-necked Snake

First row of scales on each side with small, dark markings 206.

206. With 17 rows of scales anteriorly; belly scarcely spotted; Cal.

Diadophis amabilis vandenburghi Blanchard Van Denburgh's Ring-necked Snake

Usually with not more than 15 rows of scales; belly often spotted 207.

207. Light ring on neck usually over one and one-half scales wide; belly lightly spotted; Cal. to Wash. and Idaho

Diadophis amabilis occidentalis Blanchard Western Ring-necked Snake

Light ring on neck usually under one and one-half scales wide, often interrupted on the mid-dorsal line; belly well spotted; Cal.

Diadophis amabilis amabilis (B. & G.) San José Ring-necked Snake

208. With 15 rows of scales around the posterior end of the body before the anus; back uniformly dark or with dark blotches; belly grayish or yellowish 209.

With 11 to 13 rows of scales around the posterior end of the body; color may be similar or not 211.

209. Chin plates white, with this color often extending on to the throat; back dark, with dark blotches in young; belly dark gray; usually with seven upper labials; eastern and central states to the Mississippi

Coluber constrictor constrictor (Linn.) Black Snake, Black Racer

(*Zamenis constrictor* (part) of Cope)

(*Bascanion constrictor* (Linn.))

Chin plates not white; back bluish-gray, brownish or greenish, with or without blotches; belly yellowish or bluish; with seven or eight upper labials 210.

210. Usually with seven upper labials; color above bluish, with or without blotches; central and southwestern states (A white-spotted variety, subspecies *anthicus* (Cope), is found in northwestern La.)

Coluber constrictor flaviventris (Say) Blue or Yellow-bellied Racer

Usually with eight upper labials; color above brownish or greenish; with or without blotches; West Coast to Utah

Coluber constrictor mormon (B. & G.) Green or Western Yellow-bellied Racer

211. With 15 rows of scales anteriorly 212.

With 17 rows of scales anteriorly 215.

212. Plates of head with pale borders; body striped on sides 213.

Plates of head without pale borders; body striped on sides or not so 214.

213. Stripes on sides broken up by light patches, or with light cross bands on the neck; Texas

Coluber taeniatus girardi S. & B. Texas Coach-whip Snake, Ornate Racer

(*Masticophis ornatus* of B. & G.)

Stripes of sides complete; no light cross bands on neck; Wash. to Texas and Cal.

Coluber taeniatus taeniatus (Hallowell) Striped Racer or Striped Whip Snake

214. With one or no light stripe along each side; Texas

Coluber taeniatus ruthveni (Ortenburger) Ruthven's Racer

With two light stripes along each side; Texas

Coluber taeniatus schotti (B. & G.) Texas Green Racer

215. With one or more stripes lengthwise along each side 216.

No stripes along sides; back plain or with dark cross bands or blotches 217.

216. With several dark stripes along each side; Ariz. and N. M.

Coluber semilineatus (Cope) Arizona Whip Snake

With a single pale stripe along each side; Cal.

Coluber lateralis (Hallowell) California Striped Racer

217. Back and tail completely very dark colored; belly pinkish, with dark blotches anteriorly; Ariz. and S. Cal.

Coluber flagellum piceus (Cope) Black Whip Snake

Back and tail not completely dark; back uniformly colored or with blotches or cross bands; belly pale to dark, with or without dark markings 218.

218. With a white stripe through the loreal plate; with dark cross bands on the neck; Utah southwards and to Cal.

Coluber flagellum frenatum (Stejneger) Red Racer or Red Whip Snake

No white stripe through the loreal; back banded or plain 219.

219. Back with dark cross bands anteriorly one or two scales apart, or else unbanded and with the anterior part of the body darker; N. C. southward, and westward to Kansas and Texas.

Coluber flagellum flagellum (Shaw) Coach-whip Snake

Back with dark cross bands anteriorly three or more scales apart, or else unbanded and uniformly shaded throughout; Kansas to Colo., and southwards

Coluber flagellum testaceus Say Prairie Racer
(*Masticophis flagellum flavigularis* (Hallowell))

220. With one internasal 221.
With two internasals 223.

221. Nasals meeting anteriorly on the mid-line; back brown, with a yellowish stripe along each side; belly yellow; Fla. to Ga.

Liodytes alleni (Garman) Swamp Snake

Nasals not meeting; back black, with upright bars of red along the sides; belly red, with black blotches 222.

222. Usually with 53 or more pointed red markings along each side of body; Va. to Ala. and Fla.

Farancia abacura abacura (Holbrook) Eastern Horn Snake, Red-bellied Mud Snake

Usually with 52 or less rectangular red markings along each side; Texas to western Fla. and northward to Mo. and Ind.

Farancia abacura reinwardtii (Schlegel) Western Horn Snake, Red-bellied Mud Snake

223. Prefrontal plates bordering the eyes; back and sides with light and dark brown lengthwise stripes; belly plain reddish or irregularly spotted; Texas

Coniophanes imperialis imperialis (Baird) Black-banded Snake

Prefrontal plates each separated from the eye by a preocular plate; back black, with three reddish stripes; belly red, usually with rows of dark spots; Maryland to Fla. and Ala.

Abastor erythrogrammus (Latreille) Rainbow Snake

KEY TO SOME OF THE COMMON GENERA OF SNAKES, BASED MAINLY ON THE COLOR PATTERN

1. Back mostly plain colored 2.
With stripes, bars, spots or blotches on the back or with a light band or ring around the neck 6.

2. Color above green

Opheodrys Green Snakes

Color above brownish, bluish or black 3.

3. Color above brownish 4.
Color above bluish or black 5.

4. With faint stripes
Storeria Little Brown Snakes
Color almost plain—three common genera
Carphophis Worm Snakes
Haldea Ground Snakes
Tantilla Black-headed Snakes

5. With red side bars
Farancia Horn Snake
Not so
Coluber (part) Whip Snakes and Racers

6. With narrow cross rings around the body or with a band or ring around the neck 7.
Back striped, spotted, mottled, blotched or barred 11.

7. With a light ring around the neck—two common genera
Diadophis Ring-necked Snakes
Tantilla Black-headed Snakes
With rings around the body 8.

8. With red, black and yellow rings completely encircling the body, with the yellow adjacent to the red
Micrurus Coral Snakes
Color not so 9.

9. With rattles on the tail
Crotalus Banded Rattlesnakes
No rattles on the tail 10.

10. Scales smooth
Lampropeltis (part) King Snakes
Scales keeled
Natrix (part) Water Snakes

11. Back and sides striped 12.
Back spotted, mottled, blotched or barred 13.

12. With three light stripes lengthwise along the back and sides—two common genera
Tropidoclonion Striped Swamp Snake
Thamnophis Garter Snakes
Less definitely striped—some of the species of the following genera
Natrix Water Snakes
Elaphe Chicken Snakes
Coluber Whip Snakes and Racers
Storeria Brown Snakes

13. With rattles on the end of the tail
Sistrurus Pigmy Rattlesnakes
Crotalus Larger Rattlesnakes
No rattles 14.

14. With a pit between the eye and the nostril; pupil of eye vertical
Agkistrodon Moccasin
No pit between the eye and the nostril; pupil of eye round 15.

15. Rostral plate turned up and keeled above
Heterodon Hog-nosed Snakes
Not so—some of the species of the following genera
Lampropeltis King Snakes
Natrix Water Snakes
Elaphe Chicken Snakes
Coluber Whip Snakes and Racers
Pituophis Bull Snakes
Thamnophis Garter Snakes

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Klauber (1948) has determined the names of five of our common snakes as follows: *Thamnophis ordinatus* for *T. sirtalis, Thamnophis sirtalis* for *T. sauritus, Agkistrodon contortrix* for *A. mokeson, Heterodon platyrhinos* for *H. contortrix,* and *Lampropeltis doliata* for *L. triangulum.* The names used as first choice in the snake key are those given in the fifth edition of Stejneger and Barbour's Check List.

TURTLES

CHAPTER 13

The United States is rich in numbers and species of turtles, which are widely distributed and of varied habitats. Only on the west coast do we find any reduction of the turtle fauna, where but one species, *Clemmys marmorata,* is native. The scarcity of turtles in this region corresponds with conditions in Europe, where numbers and species are much fewer than over most of our country. In several other ecological respects the life of the west coast resembles that of Europe. The two regions also share a genus of crayfish which is not found east of the Rocky Mountain area.

Turtles, although all built on the same general plan, show considerable adaptation to their environment. As a generality, it may be said that the flatter the shell, the more aquatic the turtle. The extreme is reached in the soft-shelled turtles of the genus *Amyda,* which have a height of about two inches associated with a diameter of more than a foot. The amphibious turtles, such as the spotted and the wood turtles, are of intermediate proportions, while those largely confined to land, as the box and the gopher turtles, have very high, arched shells.

Soft-shelled, mud and musk turtles are almost never seen on land. Consequently they are unknown to most people, although the name "mud turtle", which should be restricted to the genus *Kinosternon,* is often applied indiscriminately to almost any turtle. The snapping turtle, *Chelydra serpentina,* is almost entirely aquatic, especially as it matures. It has become so specialized for devouring its food under water that it is unable to swallow, unless it can submerge its head. These turtles are largely carnivorous. The snapper, because of its large size, great abundance, and clever methods of ambushing and stalking its prey, works great destruction to fish, frogs and waterfowl entering its territory. There are several cases on record where dogs have been dragged by snappers under the surface of the water, there to be drowned and ripped to pieces by the powerful claws.

The majority of turtles are amphibious, almost equally at home on land or in the water. Here we find the turtles so commonly seen basking on a log projecting from the water. These promptly prove, as one approaches, their right to the popular names of sliders and scooters. The painted turtles and the *Pseudemys* group usually prefer quiet ponds with plenty of water-lilies and submerged vegetation. The painted turtle includes in its omnivorous diet the seed pods of the water-lilies, some of the hard-coated seeds of which pass unharmed through the digestive tract to fall and develop into more turtle pasture. The geographic or map turtle and Lesueur's or the ridgeback turtle prefer more open water, while the spotted and wood turtles like small ponds and brooks, and frequently wander freely over land from one pond to another.

A few turtles are almost entirely terrestrial. The most widely distributed of these are the box turtles, which spend most of their time searching among and under leaves for choice insects and worms. Their shell pattern makes them almost invisible against a background of fallen leaves, and their habits of retiring completely into their shells and closing themselves into these "boxes", when disturbed, permit them to escape almost every enemy but forest fires. Although they occasionally raid a strawberry patch, they do much good by destroying insects. We have seen them gorged with Japanese beetles and have found them to prefer hard-shelled beetles to soft grubs or worms. Captive specimens usually take readily to bananas and meat scraps. The gopher turtle is an extreme form which has become adapted to desert conditions and digs deep burrows for itself.

Sexual differences among turtles are not great. In several species the male has a slightly concave plastron or lower shell, while the plastron of the female is slightly convex. The male usually has a slightly longer tail and proportionately longer claws than the female. In the common box turtle the male has a reddish iris to the eye, while the iris of the female is yellowish or orange. Mating usually takes place in the spring, soon after activity has been resumed. By the early summer the females are ready for egg-laying, and often travel far afield looking for suitable places in which to bury their leathery-shelled eggs. Snappers, soft-shells, mud and musk turtles lay spherical eggs. Most of the other groups lay ovoid eggs. These are left to develop by themselves and may take from six weeks to several months to hatch, depending on the temperature. It is thought that occasionally box turtles may pass the winter in the egg. The young grow slowly, but have prospects of becoming centenarians. Up to eight or ten years their age may be told with fair accuracy by the number of growth layers around the margins of the scaly plates of the shell. After that age the outer layer of these plates is shed periodically and only rough estimates are possible.

As in most of the cold-blooded vertebrates, turtles grow as long as they live, but the rate of growth drops decidedly when they reach sexual maturity, and continues to decline throughout life. Contrary to general impressions, most species of turtles grow fairly rapidly under favorable conditions. In captivity turtles, like goldfish, are seldom given conditions favorable for anything more than survival. Excluding the sea turtles, the largest members of the group are the several species of giant tortoises found on the Galapagos Islands in the Pacific Ocean and the Aldabra, Mauritius and Rodriquez Islands in the Indian Ocean. The largest turtle found in the territory covered by this book is the alligator snapper, attaining a carapace length of two feet and a weight of over a hundred pounds. The second largest is the common snapper, which may reach a carapace length of eighteen inches and a weight of fifty pounds.

The soft-shelled or leather-back turtles get to be almost as long, but not as heavy. At the other end of the scale are the spotted turtle and the musk and mud turtles, which seldom develop a carapace more than five inches long. It is a surprise to most people to learn that the little turtles commonly sold in pet shops may, under favorable conditions, attain a carapace length of ten inches.

In addition to the famous marine Green Turtle, several fresh-water forms are used for food. The best known of these is the diamond-back terrapin, which is limited in range to the salt marshes along the coast from Massachusetts to the Gulf of Mexico. It has long been a favorite with epicureans. The early American naturalist, Thomas Say, in a paper on turtles of the United States read before the Philadelphia Academy of Science in 1824 said, "It is held in high estimation as a delicate food, and is generally served up on the tables of our public eating houses, boiled in the shell." Even then its numbers were declining and other less tasty turtles were being used. In his discussion of the snapping turtle Say said, "It constitutes the chief ingredient of the more common kind of 'turtle soup' of our taverns and oyster cellars". This still holds true today, according to official reports. The wood turtle, which superficially resembles the diamond-back, has been substituted for it to such an extent that it now is protected by law in some states. The United States Bureau of Fisheries has conducted a series of experiments at the Beaufort, North Carolina, station to determine the possibilities of commercial propagation of diamond-back turtles, but few commercial growers have entered the field. Species of the *Pseudemys* group are sold in many markets.

Many pet shops stock baby turtles. These are usually the Cumberland, with a red patch on each side of the neck, and Lesueur's or the ridgeback. Occasionally a few barred terrapin (*Pseudemys concinna*), snappers and painted turtles are included. Painting a turtle is like gilding a lily and is detrimental to health and growth. Fortunately the paint may usually be pried or scraped off without damage to the turtle. If the paint is not removed, the shell will become soft or warped. All of these turtles should be provided with dry perches upon which they can climb to sun themselves. Unless they can frequently crawl out of the water to bask themselves in the sunshine, their shells gradually soften and they die a lingering death. Duckweed, a minute floating plant easily obtainable from many small ponds, should be available, as most young turtles prefer it to any other green food. Small pieces of raw meat or small worms should be fed to them every day or two, and should be removed within an hour, if not eaten. Bits of fish intestine make an especially nourishing food for most young turtles. Dr. Schmidt of the Field Museum has reported experiments indicating that canned salmon or tuna fish also renders pet turtles less susceptible to "soft shell". The "ants' eggs", which are in reality ant pupae in their cases, do not make good food for pet turtles. Continued feeding of these pupae is known to cause blindness and eventual death, possibly because of formic acid which they may contain.

Collecting Turtles

The collector must be somewhat of an ecologist and know when and where to look for each kind. Some, like the painted turtles, are commonly found in lakes and ponds with a good growth of water-lilies. Others, like the geographic, prefer more open water. Mud and musk turtles often lie on sunlit but submerged mud bars. Soft-shelled turtles prefer large, muddy rivers. Snapping turtles may occur in any body of water. Females of almost all species may be found wandering in search of suitable sites for egg-laying in the early summer. Hand or dip-net seems to be the most generally successful piece of equipment for collecting aquatic turtles, although sometimes an area may be found in which a seine may be maneuvered around the snags and brush where the more aquatic turtles hide. Floating box or barrel traps are useful, if one wants several of the same kind and does not object to drowned specimens.

A generalization as to turtle disposition may be of aid to the collector. The smaller the plastron or under shell of the turtle in proportion to the size of the upper shell or carapace, the more aggressive is the turtle. Snappers and soft-shells, apparently realizing their lack of defenses, protect themselves by vigorous aggression. Box turtles, with complete ventral armor, seldom bite and usually make docile pets.

Preserving Turtles

To preserve turtles for scientific purposes, they are best killed by injecting about ten cubic centimeters of chloroform or ether into the body cavity with a hypodermic needle. Within half an hour the animals should be completely relaxed, and ten per cent formalin can then be injected into the body cavity until the neck and legs extend in the normal walking position. The mouth should be wedged open, so that the grinding surfaces of the jaws are visible. A label may be affixed to one leg. Then the animals should be completely immersed in five per cent formalin. Stone crocks or copper wash boilers (not tinned) make good storage containers.

Identification

The names and arrangement of the outer plates or scutes of the carapace and plastron should be learned. A specimen of the box, mud or musk turtle group should be examined in order that the structure of hinges between shell sections may be understood. The nature of the jaws, serrate or smooth, and the notches or hooks in the front of the jaws are useful characters in identification. Just inside the sharp jaw edges are horny plates. These are ridged in some species and flat in others. Feet are also important in identification of turtles. Some are webbed in varying degrees, some are short-toed, some have long claws, especially in the males. Color patterns are rather variable on carapace and plastron, but fairly constant on the head and neck. Many species have large yellow or red markings on the sides of the head and neck, above and behind the eyes. The shape of these patches should be noted carefully. As with most animals, reds bleach out badly in preserved specimens.

Considerable variation in pattern or form complicates identification at times. All turtles, when young, have relatively long tails and keeled carapaces. Young soft-shells frequently show no signs of tubercles on the front margin of the carapace, although the presence or absence of tubercles in the adult enables one to distinguish species. Recently it has been shown that one supposed species, *Pseudemys troostii,* is very likely only a color phase of the adult male of *Pseudemys elegans.* If this is generally accepted, the name *troostii* will be used for both forms, since it has priority over *elegans.* Critical studies of other members of the *Pseudemys* group may show other synonomy in classification.

Problems For Study

Where turtles can be observed under natural conditions or close approximation of them, much information may be secured. We know little about food habits, beyond the fact that few, if any, are strictly carnivorous or strictly herbivorous. A few kinds are condemned because they are reported to compete with fishermen, but careful studies might show that they are of value in eliminating the unhealthy fishes slowed down by disease or parasites, or that their food may consist largely of non-game fishes, which are rivals of the game fish. It is probable that turtles, like birds, change their menu with the change in seasons.

Winter habits are also little known. Market hunters probe in swampy areas for snapping turtles during fall and spring. Wood turtles apparently winter in small streams, while box turtles burrow in soft soil. More detail on place and time of the winter rest should be recorded for all species.

Mating habits are also imperfectly known, as are incubation periods and rate of growth under normal conditions. Turtles may be marked for future recapture and study by cutting notches in the edge of the shell.

Variation from the normal in plates or scutes is interesting and of unknown significance. A not rare anomaly is the development of a double row of vertebral plates.

Variation in color also deserves study. Observations on young turtles suggest that diet and health may affect the red head-markings on some species. The gradual obliteration of the yellow markings of the shell and body of some of the males of the form known as the Cumberland terrapin, as it transforms into what was once thought to be another species, is an outstanding example of color change. This case may depend on sex hormones, a possibility open to experimental test.

OUTLINE OF CLASSIFICATION OF NATIVE TURTLES

Order TESTUDINATA (or *Chelonia*) (of Class REPTILIA)

No apparent openings in temporal region of skull; quadrate solidly fixed to skull; jaws toothless, with horny plates; body with bony or leathery carapace and plastron

Family KINOSTERNIDAE Mud and Musk Turtles

Edge of carapace not flaring; plastron crossed by two hinges, one before and one behind a central section which is immovably joined to the carapace; plastron with nine to eleven plates

Two genera — *Sternotherus* (3 species)
Kinosternon (5 species)

Family CHELYDRIDAE Snapping Turtles

Carapace and tail tuberculate; plastron small, with ten plates

Two genera — *Macrochelys* (1 species)
Chelydra (1 species)

Family TESTUDINIDAE Terrapins and Tortoises

Carapace with flaring edge; plastron with twelve plates

Nine genera — *Clemmys* (4 species)
Emys (1 species)
Terrapene (5 species)
Malaclemys (2 species)
Graptemys (4 species)
Chrysemys (2 species)
Pseudemys (11 species)
Deirochelys (1 species)
Gopherus (3 species)

Family CHELONIIDAE (Not keyed to genus and species.)

Marine turtles; limbs like flippers; carapace with horny plates; size very large

Four genera — *Chelonia* (2 species)
Eretmochelys (2 species)
Caretta (1 species)
Lepidochelys (2 species)

Family DERMOCHELIDAE (Not keyed to genus and species.)

Marine turtles; limbs like flippers; carapace leathery; size very large

One genus — *Dermochelys* (2 species)

Family TRIONYCHIDAE Soft-shelled Turtles

Carapace leathery, flat, without horny plates or scales; with a long, flexible snout

One genus — *Amyda* (5 species)

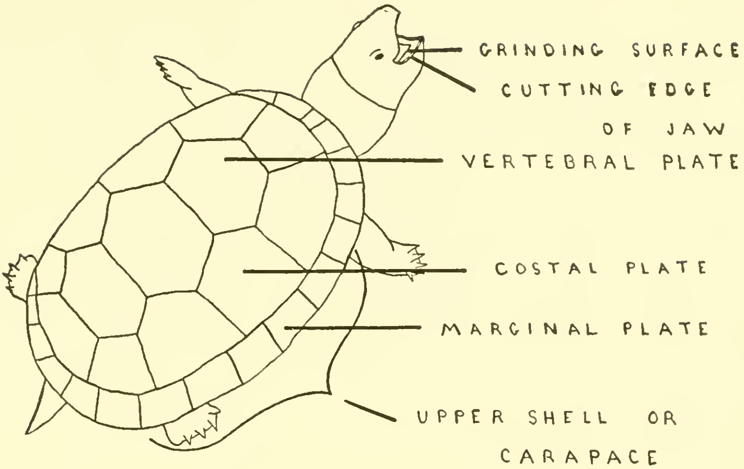
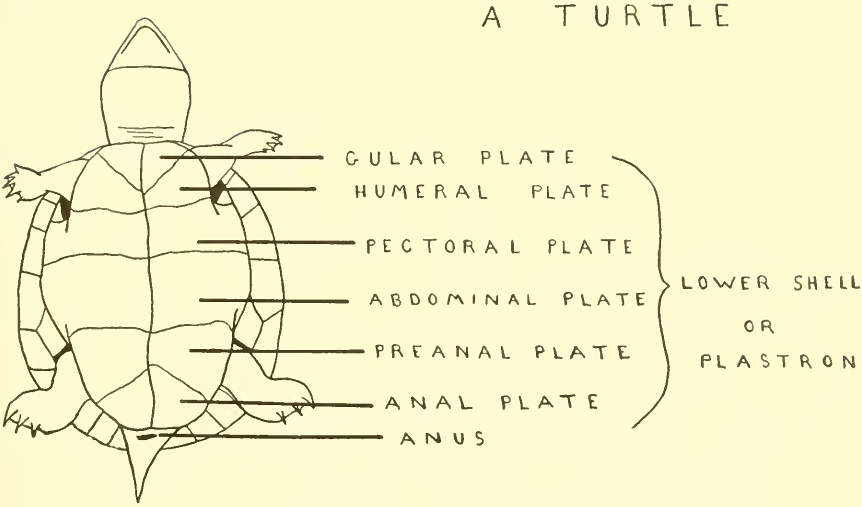


DIAGRAM OF A TURTLE



KEY TO THE PRINCIPAL SPECIES OF LAND AND FRESH-WATER TURTLES

1. Limbs like flippers
   Marine Turtles
   Limbs not like flippers; with feet for crawling 2.

2. Shell soft and leathery; Family *Trionychidae* Soft-shelled Turtles, Leatherbacks, Flapjacks 3.
   Shell composed of bony plates 6.

3. Anterior border of carapace smooth; no longitudinal ridges on the septum dividing the nostrils; Mississippi drainage, Colorado River
   Amyda mutica (LeSueur) Brown Soft-shelled Turtle, Leatherback
   Anterior border of carapace with tiny, conical, spine-like projections (sometimes absent in the young); with a longitudinal ridge in each nostril along each side of the septum dividing the nostrils 4.

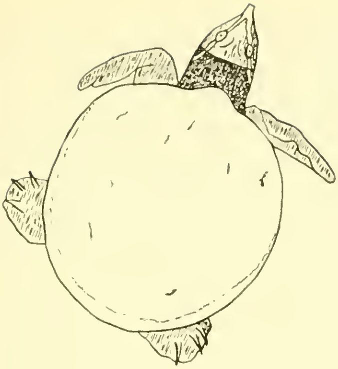
4. With two light bands on the head uniting at the base of the snout; young with black-edged dark spots on the carapace; Mississippi and St. Lawrence drainages
   Amyda spinifera (LeSueur) Spiny Soft-shelled Turtle, Flapjack
   With two light bands or faint stripes on the head uniting a little before the eyes 5.

5. Carapace oval; carapace of young with a light network separating large, dark blotches; S. C. to Florida and Louisiana
   Amyda ferox (Schneider) Southern Soft-shelled Turtle
   (*Trionyx ferox* (Schneider))
   Carapace wider behind; carapace with light tubercles; Okla. to Louisiana and California
   Amyda emoryi (Agassiz) Southwest Leatherback
   (*Aspidonectes emoryi* Agassiz)

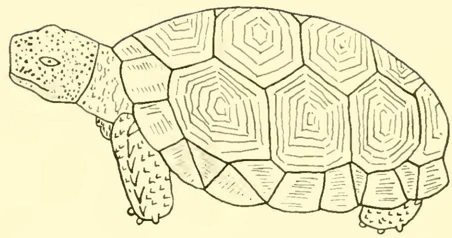
6. Plastron small, cross-shaped, or else with two transverse, cartilaginous joints and composed of nine to eleven (rarely twelve) plates 7.
   Plastron large, composed of twelve plates, and with one or no transverse hinge; Family *Testudinidae* 18.

7. Tail almost as long as the shell and with one or more rows of tubercles along the upper surface; plastron small, cross-shaped, without transverse joints; carapace flattened and with flaring edges; Family *Chelydridae* Snapping Turtles 8.
   Tail much shorter (except in the very young) and without tubercles; plastron large or small, with two transverse, cartilaginous joints; carapace high, with the edges turned downwards; Family *Kinosternidae* Mud and Musk Turtles 10.

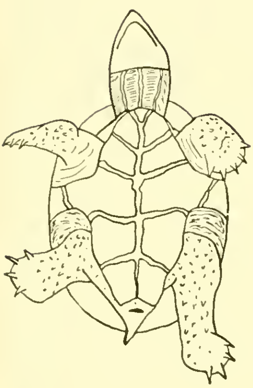
8. Tail with small scales beneath; with three high, lengthwise ridges on the carapace; edge of carapace with extra marginal plates; Ill. south; Ga. to Fla. and Texas
   Macrochelys temminckii (Troost) Alligator Snapper
   (*Macrochelys lacertina* (Schweigger))



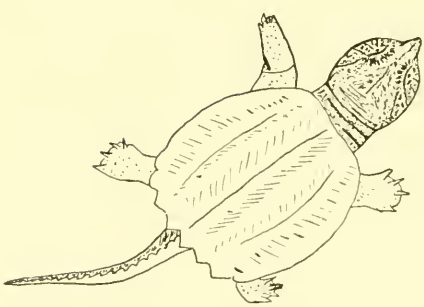
AMYDA MUTICA



GOPHERUS
POLYPHEMUS



STERNOTHERUS
ODORATUS



CHELYDRA SERPENTINA
(YOUNG)

Tail with two rows of large shields beneath; with three low, lengthwise ridges on the carapace; edge of carapace with a single row of marginal plates 9.

9. With two small chin barbels; with one row of larger tubercles along the mid line of the upper surface of the tail; U. S. east of the Rockies, excepting Florida
Chelydra serpentina serpentina (Linn.) Common Snapper
With four small chin barbels; with three or four rows of nearly equal tubercles along the upper surface of the tail; Florida
Chelydra serpentina osceola (Stejneger) Florida Snapper

10. Plastron short and narrow, not capable of closing shell; central margin of pectoral plate as long as humeral 11.
Plastron covering the soft parts, capable of almost or entirely closing the shell; central margin of pectoral plate shorter 13.

11. With two yellow stripes on each side of head; chin with lengthwise stripes; U. S. west to Okla. and Texas
Sternotherus odoratus (Latreille) Common Musk Turtle, Stink Pot
(*Aromochelys odoratus* (Latreille))
No or faint head stripes; chin spotted or mottled 12.

12. Head spotted with black; carapace with a mid-dorsal keel in both young and adult; southern Mississippi drainage
Sternotherus carinatus (Gray) Keeled Musk Turtle
Sides of head with faint stripes; with a lateral keel on each side of carapace; mid-dorsal keel present only in the young; Tenn. to Fla. and Ala.
Sternotherus minor (Agassiz) Southern Musk Turtle
(*Aromochelys tristycha* Agassiz)

13. Bridge (connection between the plastron and the carapace) very narrow, about one-third as long as the length of the plastron before the first transverse hinge; head plain dark or light speckled above; sides of neck with one or two faint stripes; Florida
Kinosternon steindachneri Siebenrock Florida Mud Turtle
Bridge about one-half as long as the front lobe of the plastron 14.

14. Sides of head striped 15.
Head spotted, blotched, or plain colored, the spots arranged in lengthwise rows on the neck in *K. subrubrum subrubrum* 16.

15. Sides of head with two narrow, light stripes; with three yellow stripes on the carapace, which become faint in old turtles; Florida
Kinosternon baurii Garman Banded Box Turtle
With two wide orange bands on each side of the head; no stripes on the carapace; Mo. to Ala. and Texas
Kinosternon subrubrum hippocrepis (Gray) Louisiana Mud Turtle
(*Cinosternum louisianae* (Baur))

16. Top and sides of head with yellow spots and blotches, which are arranged in two lengthwise rows on each side of the head; eastern U. S. to Florida, Ill. and Tenn.

Kinosternon subrubrum subrubrum (Lacépède) Common Mud Turtle

(*Cinosternum pennsylvanicum* (Gmelin))

Top of head plain dark or dark mottled 17.

17. Carapace without lengthwise keels; top of head dark; sides and under surface of head plain yellow; Neb. to Texas and Ariz.; also Ill.

Kinosternon flavescens (Agassiz) Yellow-necked Mud Turtle

Carapace with three more or less distinct lengthwise keels; top of head dark mottled; under surface of head mottled dark and light; Texas to Cal.

Kinosternon sonoriense Le Conte Arizona Mud Turtle

(*Cinosternum henrici* Le Conte)

18. Carapace and plastron united by a cartilaginous joint; with a transverse hinge across the plastron between the abdominal and pectoral plates The Box Turtles 19.

Carapace and plastron united by a bony bridge; no hinge across the plastron in this region 24.

19. Posterior margin of plastron and the upper jaw notched; carapace long-oval, black with yellow spots; Minn. and Iowa to New England

Emys blandingii (Holbrook) Blanding's Semi-box Turtle

(*Emys meleagris* (Shaw and Nodder))

Posterior margin of plastron straight or outcurved; upper jaw hooked; color of carapace variable 20.

20. Usually, but not always, wth three claws on the hind foot; no webs between the toes 21.

Usually with four claws on the hind foot; toes somewhat webbed 22.

21. Shell flaring outwards behind; with orange markings around mouth and chin; carapace with variable, obscure, yellowish markings; plastron yellow, sometimes with dark clouding; S. C. to Texas, north to Missouri

Terrapene triunguis (Agassiz) Three-toed Box Turtle

Shell very globular and not flaring much behind; with two yellow bands behind each eye; chin yellow; plates of carapace with greenish lines in a fan-like pattern; plastron plain yellow or with dark cross markings; Florida

Terrapene bauri Taylor Baur's Box Turtle

22. Toes scarcely webbed, the claws appearing to spring almost directly from a fleshy foot; plastron dark, with bright yellow stripes and bars; plates of carapace with yellow stripes in a fan-like pattern; Mont. to Ind. and Arizona

Terrapene ornata (Agassiz) Painted Box Turtle

(*Cistudo ornata* Agassiz)

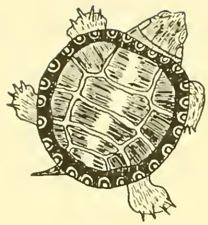
Toes about half or more webbed; plastron yellow or with dark blotches or clouding 23.

23. Carapace plain or with yellow markings arranged in radiating lines; plastron mostly yellow, with the edges of the plates tinged with dark; toes of hind feet deeply webbed; shell elongated; Ga. to Fla. and Texas

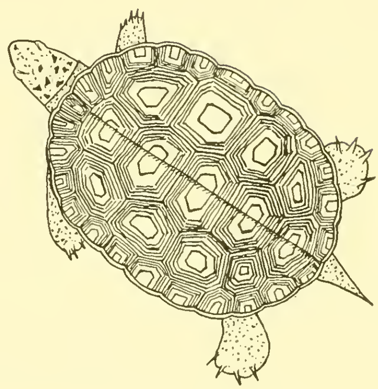
Terrapene major (Agassiz) Large Box Turtle

(*Cistudo major Agassiz*)

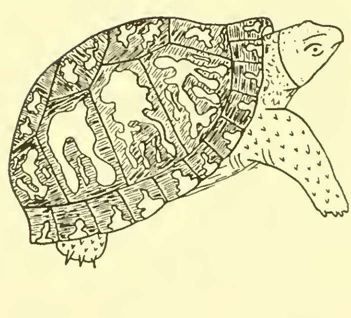
YOUNG OF
CLEMMYS GUTTATA



CHRYSEMYS PICTA PICTA
(YOUNG)



MALACLEMYS CENTRATA



TERRAPENE CAROLINA

Carapace variably marked with yellow; dark color on the plastron not confined to the edges of the plates; toes about half webbed; shell oval; Maine to Wis. and Ga.

Terrapene carolina (Linn.) Common Box Turtle

24. Feet club-shaped, not webbed; toes not distinct; claws thick and blunt; terrestrial; southern U. S. only Tortoises 25.

Hind feet somewhat webbed; claws narrow and pointed; either terrestrial or aquatic Terrapins 27.

25. Length of shell less than twice the depth; Texas

Gopherus berlandieri (Agassiz) Texas Tortoise

(*Xerobates berlandieri* Agassiz)

(*Testudo berlandieri* (Agassiz))

Length of shell more than twice the depth 26.

26. Scales of forearm uniform; front area of plastron sloping slightly upwards; Nev. and Utah to Texas and Cal.

Gopherus agassizii (Cooper) Agassiz's Tortoise

Scales of forearm not uniform, some being spiny and larger than others; front area of plastron turning sharply upwards; Fla. to S. C. and Ark.

Gopherus polyphemus (Daudin) Gopher Tortoise

27. With a ridge along the grinding surface of the upper jaw parallel with the thin, outer cutting edge; usually, but not always, with a ridge along the grinding surface of the lower jaw; plates of carapace usually smooth or with lengthwise furrows or ridges; rarely with a blunt keel along the middle of the carapace in the adult; head and neck conspicuously colored with light lengthwise stripes and markings, except in a few of the species with a serrated or fluted posterior margin of the carapace 28.

No ridge along the grinding surface of the jaws; plates of carapace usually smooth or with concentric ridges (not color markings), sometimes with a few fine lengthwise ridges in forms with a high mid-dorsal keel in the adult; species having the rear margin of the carapace serrated have a pronounced keel along the middle of the carapace in the adult; head not definitely striped in forms having the rear border of the carapace smooth 45.

28. Rear margin of the carapace smooth, except for a slight notch in the middle Chicken and Painted Turtles 29.

Rear margin of the carapace serrated or fluted Sliders, Cooters 33.

29. Marginal plates of carapace with yellow markings; with a very broad yellow band running down each front leg; head and neck about one-half as long as the shell; N. C. and Fla. to Texas and Okla.

Deirochelys reticularia (Latreille) Chicken or Long-necked Turtle

(*Chrysemys reticulatus* (Bosc))

Under marginal plates of carapace with red markings; front leg with one or more fine stripes, or else unstriped; head and neck shorter Painted Turtles or Terrapins 30.

30. Vertebral plates of carapace almost in a line with the costal plates; plastron usually plain yellow 31.

Vertebral plates definitely alternating with the costal plates; plastron usually with dark markings 32.

31. Carapace short and wide, with the vertebral plates wider than the costal plates, so that the adult of this species resembles the form of the young of the following species; with a broad, light, mid-dorsal stripe; Illinois south

Chrysemys picta dorsalis (Agassiz) Striped Painted Turtle

Carapace long-oval, with the vertebral plates about the same width as the costal plates, in the adult; with a fine, light, mid-dorsal line; New England to Florida

Chrysemys picta picta (Schneider) Eastern Painted Turtle

32. Larger plates of carapace plain dark, with narrow yellow borders; plastron with a long dark patch in the center; N. Y. to Wis. and Tenn.

Chrysemys bellii marginata (Agassiz) Western Painted Turtle

Larger plates of carapace scarcely, if any, margined with yellow, but with a fine yellow network; plastron with two dark bands running lengthwise and uniting anteriorly and posteriorly; Wash. to Ill. and Texas

Chrysemys bellii bellii (Gray) Bell's Painted Turtle

33. Ridge along grinding surface of jaws smooth; lower jaw with a thin, smooth, outer cutting edge 34.

Ridge along grinding surface of jaws tuberculate; lower jaw with a serrate edge, like the teeth of a fine saw, or sometimes smooth 36.

34. Head almost wholly dark, with obscure stripes and markings; Tennessee region (Thought to be a phase of the adult male of *P. t. elegans*)

Pseudemys troostii troostii (Holbrook) Troost's Terrapin

With a red or yellow patch of color on each side of the head behind each eye 35.

35. With a long, oval, red or orange spot behind each eye; plastron with much dark color; Ohio to Iowa and south

Pseudemys troostii elegans (Wied) Cumberland Terrapin

With an irregular, yellow cross band extending down on each side of the head from behind each eye; plastron entirely yellow or with only a few dark markings; N. C. to Florida

Pseudemys scripta (Schoepff) Yellow-bellied Terrapin
(*Chrysemys scabra* (Agassiz))

36. No projection on each side of a median notch in the upper jaw; edge of upper jaw smooth or serrate 37.

With a projection on each side of a notch in the middle of the front of the upper jaw; rest of upper jaw usually serrate 42.

37. Usually with a notch in the middle of the front of the upper jaw; stripes on top of head usually broken or with cross connections; Indiana to the Mississippi River

Pseudemys concinna hieroglyphica (Holbrook) Hieroglyphic Terrapin

No notch in middle of front of upper jaw; light lines on top of head continuous, although sometimes branched 38.

38. Upper jaw strongly serrate; usually with seven or more light lengthwise stripes between the eyes; plastron often with dusky color; Florida to Texas
Pseudemys concinna mobilensis (Holbrook) Mobile Cooter
Upper jaw practically smooth 39.

39. Plastron with a dusky blotch 40.
Plastron without dusky color 41.

40. Carapace rather low; soft parts brownish, with orange-yellow stripes; usually no vertical yellow stripe behind eye; Maryland to Alabama
Pseudemys concinna concinna (Le Conte) Barred Terrapin
Carapace more elevated; soft parts black, with greenish-yellow stripes; with a yellow stripe from above eye turned downwards across temporal region to join yellow stripes extending backwards from jaws; Florida
Pseudemys concinna suwannensis (Carr) Suwannee Terrapin

41. Light stripe across each upper ear region fused anteriorly with a light stripe on each side of mid-line of head; blotches on under sides of marginal plates wholly dark; Florida
Pseudemys floridana peninsularis Carr Peninsula Terrapin
Light stripe across each upper ear region distinct from the light stripe on each side of mid-line of head; blotches on under sides of marginal plates with light centers; N. C. to Ala. and Florida
Pseudemys floridana floridana (Le Conte) Florida Terrapin

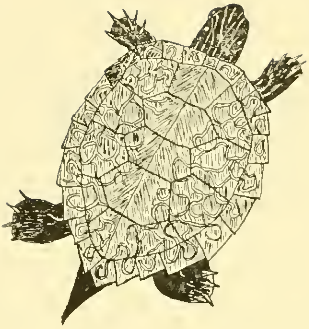
42. Some of the stripes on sides of head broken to form spots or bars; usually with a vertical yellow bar behind each eye; Texas
Pseudemys texana Baur Texas Terrapin or Cooter
Stripes on sides of head unbroken; no vertical yellow bar behind eye 43.

43. With more than ten fine, light, lengthwise stripes on top of head between the ear regions; plastron usually yellow, with fine brown markings; Fla. to La.
Pseudemys alabamensis (Baur) Alabama Terrapin
With less than ten light stripes so situated 44.

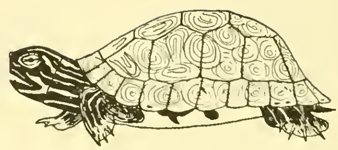
44. Blotches on under sides of marginal plates wholly dark; Florida
Pseudemys nelsoni Carr Nelson's Terrapin
Blotches on under sides of marginal plates with light centers; N. Y. to Florida
Pseudemys rubriventris (Le Conte) Red-bellied Terrapin
(*Ptychemys rugosa* (Shaw))

45. Head and neck with conspicuous yellow, lengthwise stripes and markings; sides of carapace usually flattened; rear margin of carapace serrated Map Turtles 46.
Head markings not in definite stripes; sides of carapace usually slightly convex in the adult; rear margin of carapace serrated or often practically smooth Pond Turtles and Diamond-backs 48.

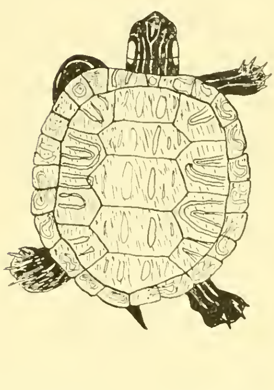
46. With a yellow mark in the form of a crescent or right angle, open toward the side, bent around behind each eye; Wis. to Ohio, Ala., and Oklahoma



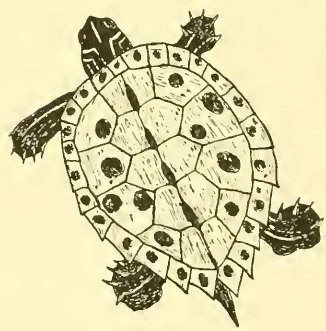
GRAPTEMYS GEOGRAPHICA



PSEUDEMYS CONCINNA
CONCINNA



PSEUDEMYS TROOSTII
ELEGANS



GRAPTEMYS
PSEUDOGEOGRAPHICA
PSEUDOGEOGRAPHICA

Graptemys pseudogeographica pseudogeographica (Gray)
(*Malacoclemmys lesueurii* (Gray)) LeSueur's Terrapin, Ridge-back

With a yellow spot behind each eye 47.

47. Carapace with a low, even, mid-dorsal keel; larger plates of carapace greenish, with a yellow network; Vermont to Texas
Graptemys geographica (LeSueur) Map Turtle

Keel on the carapace rising in the form of tubercles, making a jagged profile; yellow markings on carapace not in the form of a network, usually appearing as rings; with a broad yellow band covering chin; La. to Texas
Graptemys oculifera (Baur) Ocellated Terrapin

48. Head dark, with a large orange patch of color much larger than the eye on each side behind the eye; N. Y. and R. I. to N. C.
Clemmys muhlenbergii (Schoepff) Eastern Pond Turtle
(*Chelopus muhlenbergii* (Schoepff))

Head not so 49.

49. Body and carapace dark, with yellow spots about the size of the eye scattered over the surface; Maine to Wis. and Florida
Clemmys guttata (Schneider) Spotted Pond Turtle

Not so 50.

50. Carapace with fine yellow dots or streaks on each plate; head brown or yellow, with small dark dots or markings; rear margin of carapace practically smooth in the adult; West Coast
Clemmys marmorata (B. & G.) Western Pond Turtle

Plates of carapace with concentric dark markings or with concentric ridges; rear margin of carapace serrated; eastern species 51.

51. Head and limbs dark, tinged with reddish beneath; plastron with large dark blotches; frequenting damp woods, swamps, or wood streams; Maine to Va. and Wis.
Clemmys insculpta (Le Conte) Wood Turtle

Body grayish, with fine dark dots or markings; plastron with fine dark streaks, or unmarked; frequenting salt marshes of the Atlantic and Gulf coasts 52.

52. With a tubercle on each vertebral plate, giving the mid-dorsal keel a jagged outline; carapace usually brown or black; Gulf Coast
Malaclemys pileata (Wied) (and varieties) Diamond-back Terrapin
(*Malacoclemmys palustris* (Gmel.))

With an even mid-dorsal keel; carapace usually gray to greenish; Atlantic Coast
Malaclemys centrata (Latreille) Diamond-back Terrapin
(*Malacoclemmys palustris* (Gmel.))

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The names used as first choice in the turtle key are those given in the fifth edition of Stejneger and Barbour's Check List.

BIRDS

CHAPTER 14

Birds, because of their esthetic appeal and the mastery of flight which enables them to ignore boundaries and to appear at intervals even in the hearts of cities, have received a great deal, possibly more than their due share, of attention. Ornithology or bird study has become almost a science in itself. Since so many excellent books on birds are available, a complete discussion or identification guide to them is not given here.

A study of the anatomy of the bird will soon demonstrate adaptations for flight that constitute one of the most remarkable chapters in the story of evolution. A few fairly complete fossil skeletons connect the modern birds with their reptilian ancestors. Two fairly complete skeletons and several fragments from the Jurassic Period might well be taken for remains of some of the small, bipedal dinosaurs, but for the imprints of feathers. These early birds, *Archaeopteryx* and *Archaeornis,* lacked the modifications of skeleton necessary for flight, but probably used their well developed fingers and toes for climbing, and then glided down like modern flying squirrels. A South American bird, the Hoatzin, does almost the same thing today. Fossil skeletons of two kinds of sea birds, several million years younger than the others, are known as *Hesperornis* and *Ichthyornis,* and show an almost modern type of bird skeleton, but possess teeth and some other reptilian skull characters. The modern bird has reduced its hand to traces of three fingers and lost at least one toe from each foot. Its arm and leg bones are hollow; its tail shortened to a few vertebrae and a bony end-piece representing the rest; its neck is long and extremely flexible, compensating for its almost rigid trunk; its lungs are supplemented by air sacs, which extend from the lungs between the viscera, the muscles, and even into the cavities of the hollow bones. Even the outer covering of feathers is peculiarly adapted to aid flight, by reducing air resistance. In the odd groups of birds which have lost the power of flight, the feathers no longer form this smooth coat, but are downy or even hair-like.

The power of flight has permitted a remarkable development of migratory habits. The interested student should study the main "flyways" of North America, and the order and dates of movements in his locality. Now that bird-banding, started about 1710 and carried on under the direction of the United States Biological Survey since 1920, has given us a fairly clear picture of the paths, rate of movement and destinations of birds, some of the mystery has been dispelled, but by no means all. We no longer speculate, as did even good scientists a hundred and fifty years ago, as to whether swallows migrate or descend into the ponds to hibernate, but we still do not know why they migrate. Several logical theories have been suggested, but no one fits all cases. One of the oldest ideas is that the migration is to keep near a good food supply. However, some birds migrate at a time when food is abundant in the place they leave. Another theory is that the development of the sexual organs initiates the migratory urge. This is supported by the fact that the permanent residents show little seasonal change in the condition of the gonads, while the migratory birds show marked changes. In some forms, as in the bobolink, this seasonal change is correlated with changes in plumage. The argument against the sexual-cycle theory of migration is that some forms which take more than one year to mature, such as the Trumpeter Swan, Blue Goose and Whooping Crane, migrate in their first year. Whatever the cause of migration, it remains one of the greatest wonders of animal life. The longest migration is made by the Arctic Tern, which nests within eight degrees of the north pole and after about fourteen weeks starts a trip of over eleven thousand miles to the edge of Antarctica. The longest continuous flight is that made by the Golden Plover, which, in its autumn trip from the Arctic to South America, makes a non-stop flight of 2,500 miles from Nova Scotia to Argentina. It returns by a different route, traveling up the Mississippi Valley, two thousand miles west of its autumn trip. This use of different routes for spring and fall migration is not confined to the Golden Plover, but has also been shown for the Connecticut Warbler, which starts its fall migration by travelling eastward from southern Canada to New England, and flies down along the coast to Florida, returning in spring by the Mississippi Valley. The Pacific Golden Plover has the most remarkable migration path, since it navigates the Pacific Ocean, from Alaska to Australia and southeastern Asia, making stops in the Midway, Hawaiian and South Sea Islands. Banding has also revealed that some birds, including the bobolink, are gradually changing their migration routes.

In addition to their undoubted value to the farmer and gardener as destroyers of unwanted insects, birds play a much more important part than is generally realized in helping to maintain the balance of plant life in fields and forests. Now that we are gradually learning the value of diversity in forest plantings and the value of cover and food plants, we are becoming aware that the birds, which share the benefits of these with other forms of wildlife, are responsible for much planting. Many berries and other fruits eaten by birds have hard, resistant seeds, which pass unharmed through the birds' digestive tracts and are spread far and wide. This spreading of plants usually occurs in waste places and, with the exception of poison ivy, does little harm to man and much good to animals.

Only an expert can identify more than a few birds in flight or at a distance. Portraits of Wilson and Audubon, our greatest early American ornithologists, usually show them with their shot-guns at hand. Since modern ideas of conservation prohibit the use of shot-gun and snare, field observation of the characters upon which classification depends is almost impossible. The beginner is strongly advised to devote considerable time at first to the study of mounted specimens in a museum or, if a museum is not available, to the study of a set of good bird pictures. By the use of a general outline of classification, such as the one given here, he can learn the characteristics of the principal families, and can then use any of the standard bird books to follow up the study to species. It will be noted that, in most handbooks on birds, the keys are based largely on color and the few outstanding peculiarities which can be seen in the field. This grouping by color makes the learning of bird classification seem hopeless without a foundation of museum or book study.

For field study, a small notebook and a pair of 6X or 8X field glasses are needed. Birds are usually most actively feeding and easily watched in the first two or three hours of daylight. Most of them retire into secure hiding places later in the day, when one can get only hasty glimpses of them. Usually the best policy is to seek a likely place, such as a shrubby forest edge near water, and to attempt to imitate a stump until the birds become accustomed to one's presence. The field glasses should be achromatic or, when one looks at a bird in the tree tops, it will appear, even though it be a dull-colored starling, to wear a halo of rainbow hues. The notebook is to enable one to record data that will aid in identifying the bird later.

A few pointers may be helpful. First, check on size, using such standards as the familiar English (house) sparrow, the robin and the crow. Next, record any distinctive color patches and their positions. If possible, try to determine the shape of the beak—whether it is the short, heavy, seed-crushing beak of the sparrow, the long, slender, probing beak of the thrush, the minutely hooked beak of the flycatcher, or the prominently hooked beak of the bird of prey. If the bird has any particular call or song, try to record that either by words, as "phoebe" or "bob-white", or by a slanting line that curves up and down as the notes rise and fall. Note also the habitat, whether tree-tops, bushes or ground. If the bird flies, notice whether its flight is straight or undulating, and whether it pulls in its neck and legs or flies with them outstretched.

Study of the nests and eggs is also fascinating. Fortunately, laws restrict the collection of eggs but, when the young have flown, the nests may be collected and no harm done. In observing a nest, care should be taken not to disarrange the surroundings or it may be exposed to sun and rain or to the prowling cat. Above all, one should not handle eggs or young birds, or the parents will be quite likely to forsake them. Several good books on eggs and nests are available and repay study.

Recognition of bird songs is difficult unless one has a keen appreciation of pitch and rhythm. Much time spent in actual observation of singing birds is the only way to acquire a real knowledge of their songs. Books are not of great value here, since the voice mechanism of the bird is anatomically different from that of the other animals, so that ordinary musical notation is altogether inadequate. Words or phrases are often used to represent songs, but are usually of little value except as a convenient method of recalling to one something that he already knows. With the exception of a few calls such as those of the whip-poor-will or bob-white, the commonly printed phrases, such as the "more wet wetter wet chee zee" given for the white-crowned sparrow, are of little use to the beginner. Accurate human imitations of bird songs are now available on phonograph records. Recently there have appeared on the market records of actual recordings of wild birds' songs, made under the guidance of noted ornithologists of Cornell University and the American Museum. These records, although somewhat marred by the unpreventable inclusion of the noise of the recording apparatus, are highly recommended and give a useful foundation for field study.

Two activities which can be carried on in almost any locality and which are of much help in encouraging local bird life are winter and spring feeding, and providing nesting sites and shelters. Food is often needed during deep snows and after sleet storms, especially in early spring when the migrants may be returning slightly ahead of favorable weather and, in some cases, weak from long flights. Suet, doughnuts, bird-seed and breadcrumbs are all welcome. Wild birds should not be expected to come readily to a window shelf or other open location where their instincts or experiences warn them that danger may lurk. The best place for a feeding station is near bushy shrubbery, through which the birds may approach and to which they may retreat, if alarmed. Metal feeding trays or racks should not be used in freezing temperatures. The furnishing of suitable nesting sites has become necessary in many localities because pruning, tree surgery, and elimination of bushy hedges have resulted in a shortage of natural nesting sites. This has possibly had as much to do with the decrease of such birds as the bluebird as has the introduction of such forms as the European house sparrow. Both the familiar box type and the equally useful shelf or open type are needed, and should be of subdued color, provided with drainage, and placed at suitable heights for the particular kinds of birds they are designed to harbor. Dimensions of boxes and proper locations and heights are given in many bird books and in state and federal bulletins. It should be remembered that, if such pugnacious birds as the house sparrow and the house wren are encouraged to nest in a garden, the chances of attracting any of our shyer birds are much decreased. Unfortunately, nesting boxes are seldom furnished for any birds but wrens, although many will use them, if the location suits them.

If opportunity offers, one should try to learn all that he can about the habits and every-day life of the birds. He should not make the beginner's mistake of working solely for a check list. The mere fact of having seen thirty or forty kinds of birds in one day is not especially commendable in itself and adds little to our knowledge. In almost every part of the country check lists of all the birds common to the region are already available. What is now needed is more study of birds (and other animals) as living things.

OUTLINE OF CLASSIFICATION OF NATIVE BIRDS

Subclass NEORNITHES (of Class AVES) Typical Birds

Superorder NEOGNATHAE Modern Flying Birds

Order GAVIIFORMES Loons

Water birds; legs short and placed far back; tarsus flattened; front toes webbed and with claws; with a small hind toe on each foot; beak with smooth edges

Family GAVIIDAE

With the characters of the order

(1 genus, 3 species)

Order COLYMBIFORMES Grebes

Water birds; legs short and placed far back; tarsus flattened; front toes lobed and with flattened nails; with a small hind toe on each foot; beak with smooth edges; apparently no tail

Family COLYMBIDAE

With the characters of the order

(3 genera, 6 species)

Order PROCELLARIIFORMES Tube-nosed Swimmers

Sea birds; nostrils opening through a tube or tubes

Family DIOMEDEIDAE Albatrosses

Nostrils opening through two tubes situated one on each side of the beak

(2 genera, 3 species)

Family PROCELLARIIDAE Shearwaters, Fulmars and Petrels

Nostrils opening through a single tube on top of the beak; with more than ten primaries

(3 genera, 7 species)

Family HYDROBATIDAE Storm Petrels

Nostrils opening through a single tube on top of the beak; with ten primaries

(3 genera, 6 species)

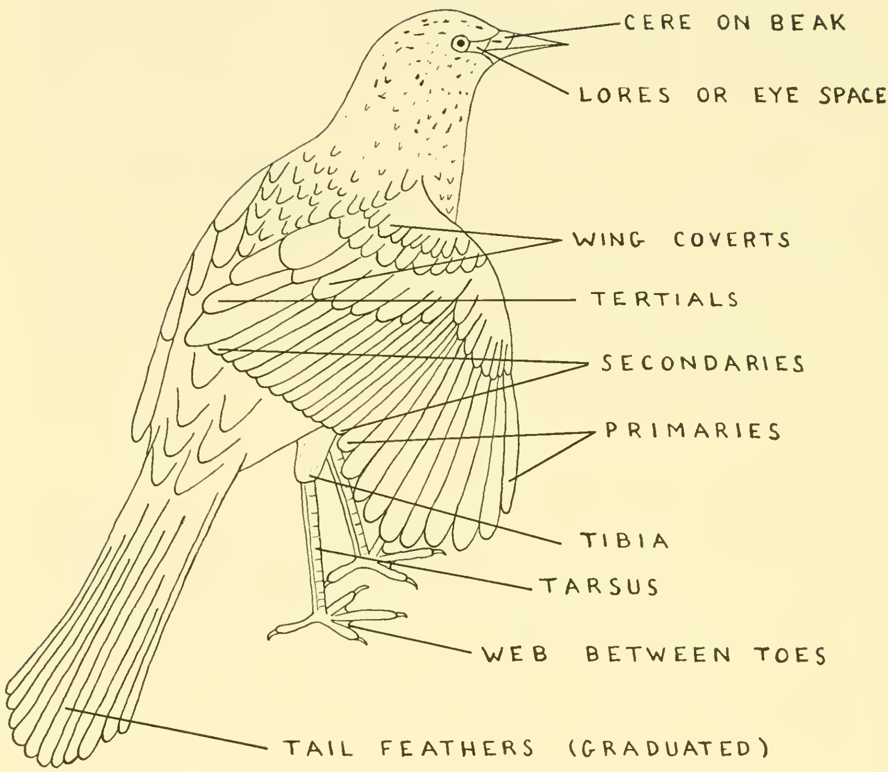


DIAGRAM OF A BIRD

Order PELECANIFORMES Totipalmate Swimmers

Water birds; legs short; web including hind toe

Family PHAETHONTIDAE Tropic-birds

Lores feathered; chin feathered; beak straight and pointed

(1 genus, 1 species)

Family PELECANIDAE Pelicans

Lores bare; beak hooked and with a large pouch beneath

(1 genus, 2 species)

Family SULIDAE Gannets and Boobies

Lores bare; chin bare; beak not hooked; tail pointed

(2 genera, 2 species)

Family PHALACROCORACIDAE Cormorants

Lores bare; end of beak hooked; no pouch beneath beak

(1 genus, 5 species)

Family ANHINGIDAE Darters, Snake-birds

Lores bare; chin bare; beak not hooked; end of tail square

(1 genus, 1 species)

Family FREGATIDAE Man-o'-war-birds

Lores feathered; end of beak hooked

(1 genus, 1 species)

Order CICONIIFORMES Herons, Storks, Flamingos, etc.

Water birds; legs very long; tibia bare below; lores bare; usually large, long-necked birds

Suborder ARDEAE Herons, Bitterns, etc.

Toes four, all on the same level, scarcely or not webbed

Family ARDEIDAE Herons, Bitterns and Egrets

Beak straight and pointed; middle claw serrated

(11 genera, 12 species)

Family CICONIIDAE Storks and Wood Ibises

Beak narrow, cylindrical, somewhat curved downwards; sides of upper bill not grooved; middle claw smooth

(1 genus, 1 species)

Family THRESKIORNITHIDAE Spoonbills and Ibises

Either with the end of the beak broad and flat (Spoonbills) or with the beak narrow, cylindrical, somewhat curved downwards and with the sides of upper bill grooved (Ibises) ; middle claw smooth

(3 genera, 4 species)

Suborder PHOENICOPTERI Flamingos

Feet webbed in front

Family PHOENICOPTERIDAE Flamingos

Edges of beak with serrated strainers; end of beak bent

downwards; adults rose-red
(1 genus, 1 species)

Order ANSERIFORMES Swans, Geese and Ducks

Water birds; legs short, placed moderately well back; toes webbed in front; edges of beak fringed or serrated

Family ANATIDAE

With the characters of the order

Subfamily CYGNINAE Swans

Lores bare; neck as long as the body
(1 genus, 2 species)

Subfamily ANSERINAE Geese

Lores partly or wholly feathered; beak broad and flat; tarsus with rounded scales
(4 genera, 8 species)

Subfamily DENDROCYGNINAE Tree Ducks

Lores partly or wholly feathered; beak broad and flat; lower part of tarsus with small, rounded scales; tarsus with transverse or squarish scales above
(1 genus, 2 species)

Subfamily ANATINAE Dabbling Ducks

Lores partly or wholly feathered; beak broad and flat; front of tarsus completely with transverse or squarish scales; hind toe scarcely or not lobed
(8 genera, 13 species)

Subfamily NYROCINAE Diving Ducks

Lores partly or wholly feathered; beak broad and flat; front of tarsus completely with transverse or squarish scales; hind toe with a broad flap; tail feathers soft
(8 genera, 15 species)

Subfamily ERISMATURINAE Ruddy Ducks

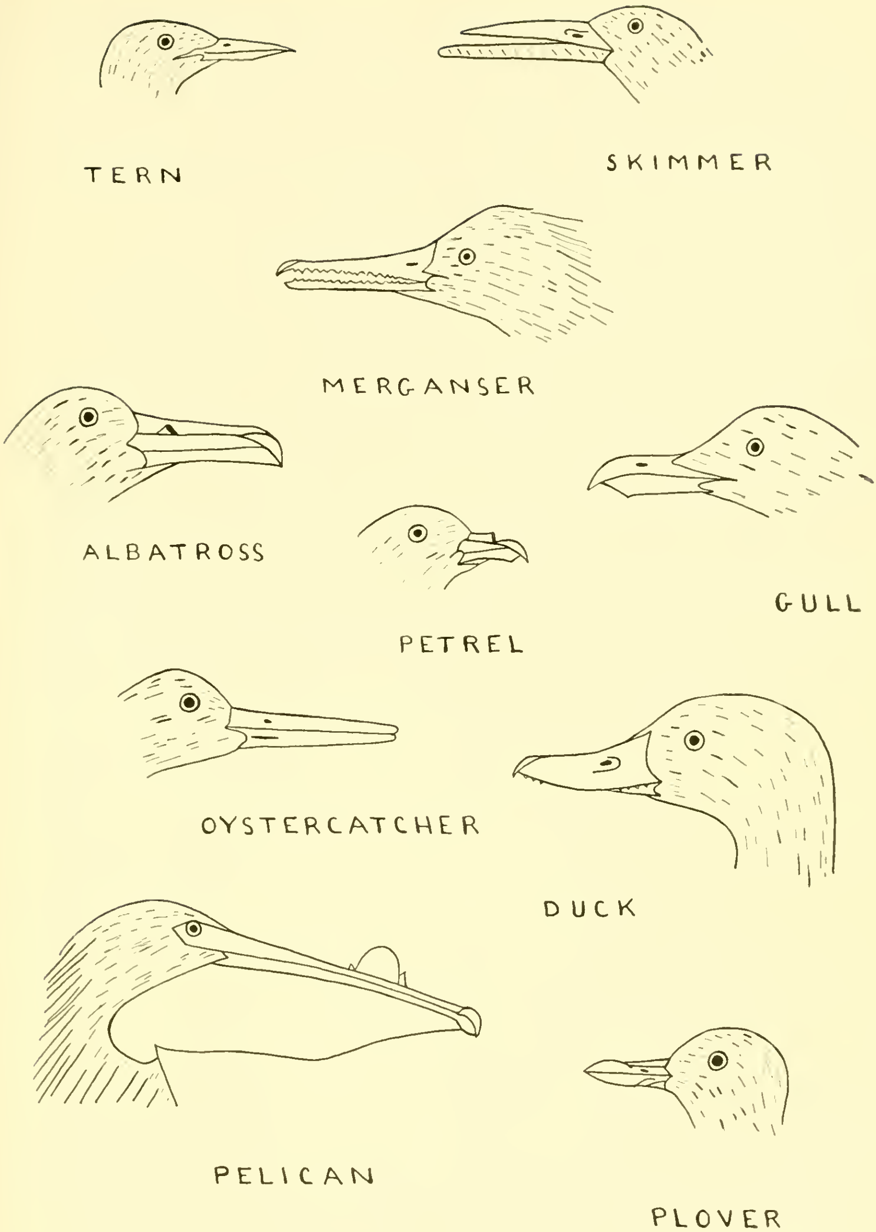
Same as preceding, except for stiff and often erect tail feathers
(2 genera, 2 species)

Subfamily MERGINAE Mergansers

Lores partly or wholly feathered; beak long and narrow and serrated along the edge
(2 genera, 3 species)

Order FALCONIFORMES Birds of Prey

Land birds; tibia feathered; toes scarcely or not webbed; nostrils much lengthened, parallel with beak, or else opening through a fleshy membrane or covering of skin (cere) at the base of the



VARIOUS TYPES OF HEADS

beak; beak pointed, hooked, with narrow lower bill, adapted for a flesh diet; with four toes, three before and one behind, sometimes with the outer one reversed; eyes directed sideways

Suborder CATHARTAE American Vultures

Head usually bare; plumage of native species black; large, long-winged birds, ordinarily seen soaring

Family CATHARTIDAE Vultures

With the characters of the suborder

(3 genera, 3 species)

Suborder FALCONES Hawks, Eagles, Falcons, etc.

Head usually well feathered

Family ACCIPITRIIDAE Kites, Hawks, Eagles, etc.

Beak not toothed or notched

(14 genera, 23 species)

Family FALCONIDAE Falcons

With a projection from each side of the tip of the upper bill fitting into a notch in each side of the lower bill

(2 genera, 7 species)

Order GALLIFORMES Gallinaceous Birds

Land birds; tibia feathered; toes usually slightly webbed; feet with short hind toe elevated above the rest or else feet small and weak; wings short and wide; fowl-like

Family CRACIDAE Curassows and Guans

Hind toe on the same level as the rest; beak with cere

(1 genus, 1 species)

Family TETRAONIDAE Grouse

Hind toe elevated; tarsus feathered; head feathered

(7 genera, 11 species))

Family PERDICIDAE Quails

Hind toe elevated; tarsus bare; head feathered

(5 genera, 7 species)

Family PHASIANIDAE Pheasants

Hind toe elevated; head partly bare

(Species introduced from China)

Family MELEAGRIDIDAE Turkeys

Hind toe elevated; head almost entirely bare and with comb, wattles or other growth

(1 genus, 1 species)

Order GRUIFORMES Cranes, Rails and Limpkins

Shore birds; legs very long; tibia bare below; hind toe about on the same level as the rest, or else large birds, over thirty inches long; toes usually not webbed; lores feathered or haired; sometimes with a bare area on the forehead; wings rather short and wide

Family GRUIDAE Cranes

Lores haired

(1 genus, 2 species)

Family ARAMIDAE Limpkins

Lores feathered; tail feathers short and stout

(1 genus, 1 species)

Family RALLIDAE Rails, Gallinules and Coots

Lores feathered; tail feathers very short and soft; forehead with a bare area in some species

(8 genera, 11 species)

Order CHARADRIIFORMES Gulls, Auks, Sandpipers, etc.

Shore or sea birds; nostrils not tubular; beak with smooth edges

Suborder CHARADRII Jacanas and Shore Birds

Legs very long; tibia bare below (except in the woodcock); hind toe elevated or absent; front toes seldom fully webbed (except in the avocets); lores feathered; beak usually adapted for probing (except in the plovers); wings long and narrow

Family JACANIDAE Jacanas

With fleshy lobes extending from the base of the beak up over the forehead; middle toe, including claw, longer than tarsus

(1 genus, 1 species)

Family HAEMATOPODIDAE Oyster-catchers

Beak long, hard, compressed sideways at tip; front of tarsus with small, rounded scales

(1 genus, 2 species)

Family CHARADRIIDAE Plovers and Turnstones

Beak short and hard, not compressed sideways at tip (compressed behind the tip in the plovers); front of tarsus with small, rounded scales

(7 genera, 11 species)

Family SCOLOPACIDAE Woodcock, Snipe, Sandpipers and Curlews

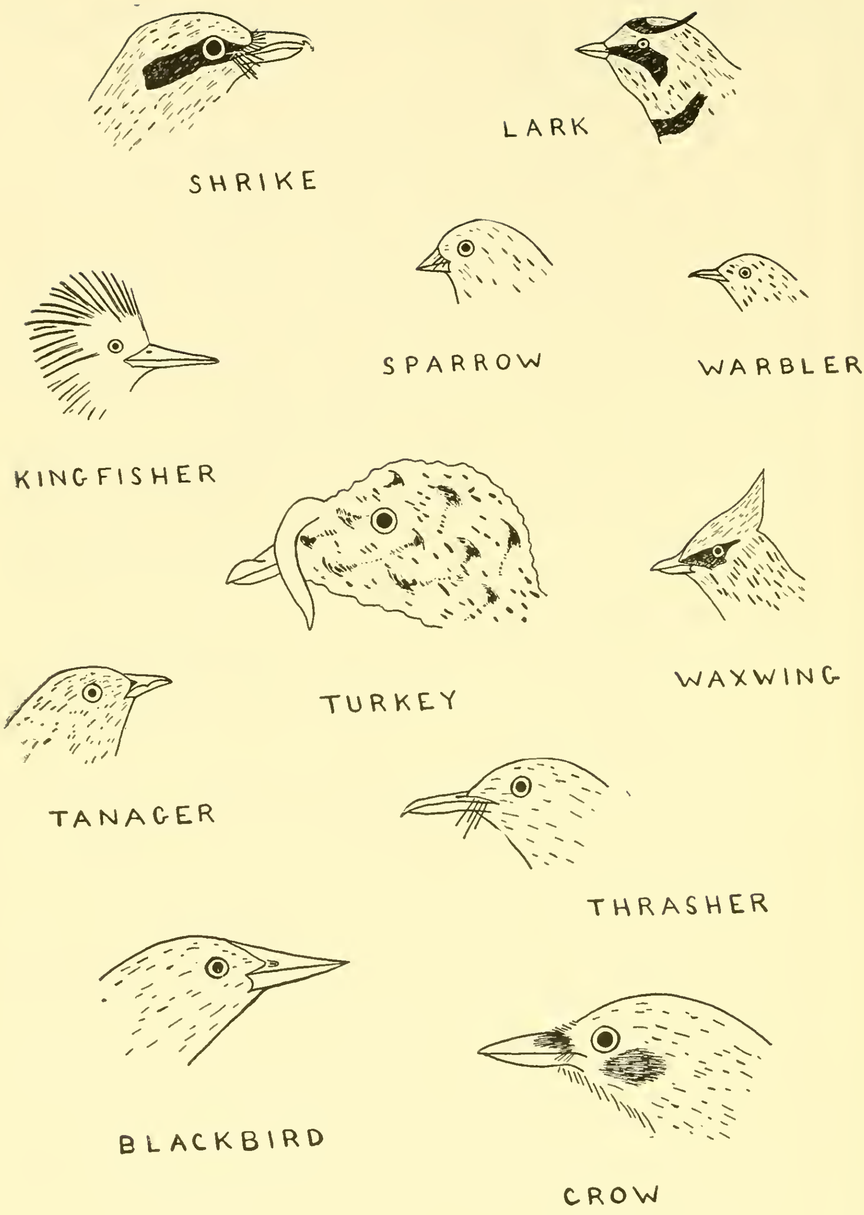
Beak long and cylindrical, soft and sensitive for probing; with transverse or squarish scales on front of tarsus; toes not lobed; sometimes with short webs between the toes

(21 genera, 27 species)

Family RECURVIROSTRIDAE Avocets and Stilts

Bare area of tibia much longer than middle toe and claw; beak upcurved (avocets) or straight (stilts)

(2 genera, 2 species)



VARIOUS TYPES OF HEADS

Family PHALAROPODIDAE Phalaropes

Toes with side webs or lobes; tarsus flattened

(3 genera, 3 species)

Suborder LARI Gulls, Terns, Skimmers, etc.

Legs short, centrally placed; toes usually four (three in one genus); feet webbed in front; beak sharply pointed, often hooked, adapted for a fish diet; wings long and narrow

Family STERCORARIIDAE Jaegers and Skuas

Upper bill in more than one piece, with a cere at the base and a swollen, hooked tip

(2 genera, 5 species)

Family LARIDAE Gulls and Terns

Upper bill in one piece, either hooked (gulls) or straight (terns)

(10 genera, 27 species)

Family RYNCHOPIDAE Skimmers

Beak straight; lower bill longer than the upper

(1 genus, 1 species)

Suborder ALCAE Auks, Puffins, etc.

Sea birds; legs short, placed very far back; tarsus flattened; with three toes, webbed and with narrow claws; wings rather short and wide

Family ALCIDAE Auks, Murres and Puffins

With the characters of the order

(11 genera, 16 species)

Order COLUMBIFORMES Pigeon-like Birds

Land birds; tibia feathered; with four toes, all on the same level, scarcely or not webbed; nostrils opening through a fleshy membrane or covering of skin (cere) at the base of the beak; beak slender, straight

Family COLUMBIDAE Pigeons and Doves

With the characters of the order

(6 genera, 8 species)

(1 extinct genus and species and several introduced species of various genera)

Order PSITTACIFORMES Paroquets and Parrots

Land birds; tibia feathered; toes permanently two before and two behind, not webbed; beak with cere; lower bill scoop-shaped; beak adapted for a vegetarian diet

Family PSITTACIDAE Paroquets and Parrots

With the characters of the order

(1 genus, 1 species now extinct)

Order CUCULIFORMES Cuckoo-like Birds

Family CUCULIDAE Cuckoos and Roadrunners

Land birds; tibia feathered; tarsus mostly bare; toes two before and two behind, not webbed; beak long, with smooth edges; nostrils exposed, brownish or grayish above; with soft tail feathers

(3 genera, 6 species)

Order STRIGIFORMES Owls

Land birds; tibia feathered; toes three before and one behind, not webbed, the outer toe reversible; beak with a cere; eyes directed forward; usually with a facial disc

Family TYTONIDAE Barn Owls

Middle claw serrate; no ear tufts

(1 genus, 1 species)

Family STRIGIDAE Horned Owls, Barred Owls, etc.

Middle claw not serrate; with or without ear tufts

(11 genera, 17 species)

Order CAPRIMULGIFORMES Goatsuckers, etc.

Family CAPRIMULGIDAE Nighthawks and Whip-poor-wills

Land birds; tibia feathered; feet small and weak; beak short and small; gape very wide; usually with bristles around the mouth; wings long and narrow; claw on middle toe serrate; feathers downy

(4 genera, 6 species)

Order MICROPODIFORMES Swifts and Hummingbirds

Land birds; tibia feathered; feet small and weak; wings long and narrow; claw on middle toe not serrate; feathers smooth

Family MICROPODIDAE Swifts

Beak short and small; gape very wide; often with spines extending from the ends of the tail feathers; birds usually seen on the wing and often mistaken for swallows

(3 genera, 4 species)

Family TROCHILIDAE Hummingbirds

Very small birds; beak long and slender; plumage shining

(10 genera, 15 species)

Order TROGONIFORMES

Family TROGONIDAE Trogons

Land birds; tibia feathered; toes two before and two behind, not webbed; tail feathers soft; beak short, with serrate edges; nostrils concealed; tarsus mostly feathered; greenish above

(1 genus, 1 species)

Order CORACIIFORMES Kingfishers, etc.

Family ALCEDINIDAE Kingfishers

Land birds; tibia feathered; feet small, with four toes, with the middle and outer toes joined for about half their length; grayish or bluish birds, with long, straight beaks, usually seen near water

(2 genera, 3 species)

Order PICIFORMES Woodpeckers, etc.

Family PICIDAE Woodpeckers

Land birds; tibia feathered; toes two before and two behind, not webbed; with stiff, pointed tail feathers; beak strong, adapted for excavating

(10 genera, 22 species)

Order PASSERIFORMES Perching Birds

Land birds; tibia feathered; no cere on beak; feet of normal size, with the hind toe about as long as the front, middle toe, on the same level as the rest, with its claw as long as or longer than that of the middle toe; toes not webbed, not united except sometimes at the basal segments; tail with twelve feathers; this group includes most of our perching and song birds

Family COTINGIDAE Cotingas

Basal segment of inner toe united with the basal segment of the middle toe

(1 genus, 1 species)

Family TYRANNIDAE Tyrant Flycatchers

With the first two primary feathers almost equal in length; tarsus rounded and scaled behind; beak wide at base, slightly hooked; with bristles at the base of the beak; head usually slightly crested; feathers usually greenish or grayish

(11 genera, 31 species)

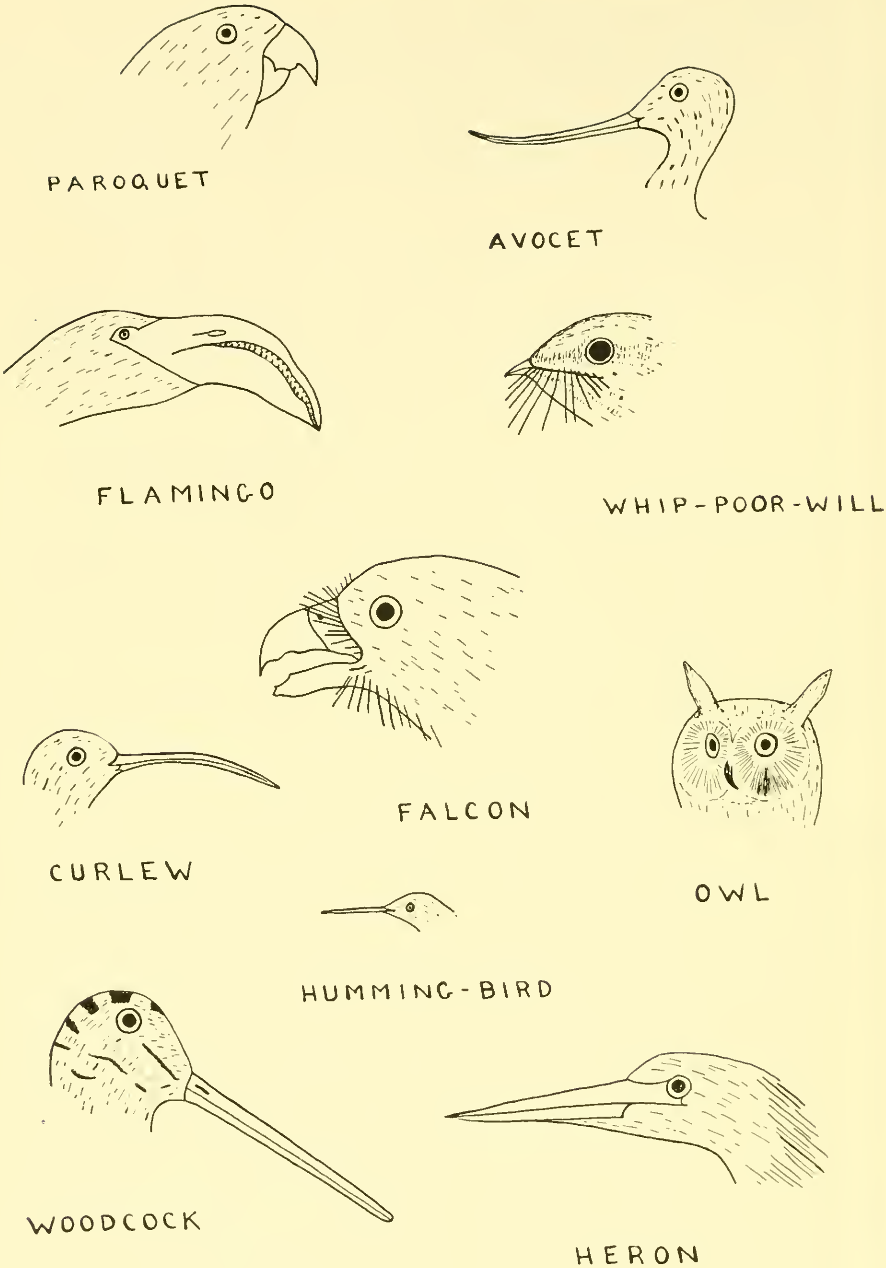
Family ALAUDIDAE Larks

With the first two primary feathers almost equal in length; tarsus rounded and scaled behind; hind claw very long; beak stout; nostrils with short bristles; usually with a tuft on each side of the head

(1 genus, 1 species)

Family HIRUNDINIDAE Swallows

First primary feather almost or quite the longest; tarsus scaled in front and with an almost bare ridge behind; beak very wide at base, without bristles; birds with notched or forked tails and very long, pointed wings, usually seen



VARIOUS TYPES OF HEADS

only in flight
(7 genera, 9 species)

Family CORVIDAE Crows and Jays

Usually with ten primaries, the first more than one-half and less than two-thirds the second; tarsus scaled in front and with an almost bare ridge behind; beak straight; nostrils mostly concealed by tufts of tiny, bristly feathers, which project forward over them; tail feathers graduated; birds larger than a robin
(8 genera, 16 species)

Family PARIDAE Titmice and Chickadees

Usually with ten primaries, the first less than two-thirds, usually less than one-half the second; tarsus scaled in front and with an almost bare ridge behind; beak straight, short and stout; nostrils mostly concealed by tufts of tiny, bristly feathers; tail feathers graduated; small birds
(4 genera, 12 species)

Family SITTIDAE Nuthatches

Usually with ten primaries, the first less than two-thirds, usually less than one-half the second: tarsus scaled in front and with an almost bare ridge behind; beak straight, long and slender; nostrils mostly concealed by tufts of tiny, bristly feathers; end of tail square; small birds
(1 genus, 4 species)

Family CERTHIIDAE Creepers

With ten primaries, the first less than one-half the second; tarsus scaled in front and with an almost bare ridge behind; nostrils exposed; beak slender, curved, not hooked at tip; tail feathers stiff and pointed, graduated; birds usually seen running up and down trees
(1 genus, 1 species)

Family CHAMAEIDAE Wren-tits

With ten primaries, the first less than two-thirds but more than one-half the second; tarsus scaled in front and with an almost bare ridge behind; beak short and stout, with small feathers projecting forward over base; nostrils exposed; tail feathers graduated; small birds
(1 genus, 1 species)

Family CINCLIDAE Dippers

With ten primaries, the first less than two-thirds the second: tarsus almost without scales: no bristles at the base of the beak; tail very short
(1 genus, 1 species)

Family TROGLODYTIDAE Wrens

With ten primaries, the first less than two-thirds but more than one-half the second; tarsus scaled in front and with an almost bare ridge behind; beak slender, not hooked, without conspicuous bristles at base; nostrils exposed; tail feathers graduated; birds usually smaller than a robin
(9 genera, 9 species)

Family MIMIDAE Mocking-birds

With ten primaries, the first less than two-thirds but more than one-half the second; tarsus scaled in front and with an almost bare ridge behind; beak slender, somewhat curved, not hooked, usually with erect bristles at base; nostrils exposed; tail feathers graduated; birds about the size of a robin
(4 genera, 10 species)

Family TURDIDAE Thrushes and Bluebirds

With ten primaries, the first very short, less than one-third the second; tarsus almost without scales; tip of upper bill notched; with bristles at the base of the beak; end of tail usually square; moderate sized birds
(6 genera, 12 species)

Family SYLVIIDAE Warblers, Gnatcatchers, Kinglets

With ten primaries, the first about one-third the second; tarsus without scales behind and usually unscaled before; beak slender, sometimes slightly notched at the tip; tail long and graduated; very small birds
(3 genera, 4 species)

Family MOTACILLIDAE Wagtails and Pipits

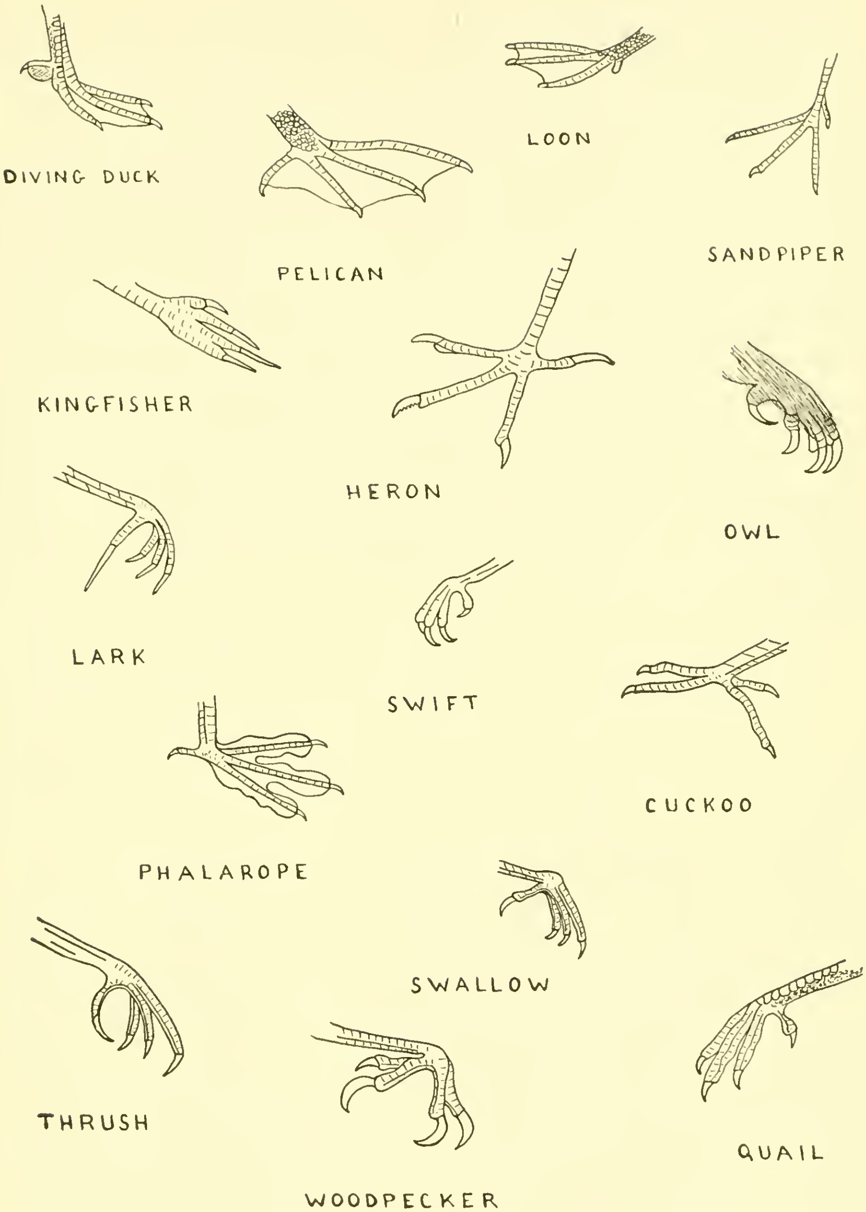
Apparently with nine primaries, the first two almost equal in length; tarsus scaled before and with an almost bare ridge behind; hind claw much lengthened; inner secondaries about as long as the primaries in the closed wing
(1 genus, 2 species)

Family BOMBYCILLIDAE Waxwings

Apparently with nine primaries, the first two almost equal in length; tarsus scaled before and with an almost bare ridge behind; beak short and wide, slightly notched near tip; no bristles at the base of the beak; nostrils concealed by tiny feathers; head crested; end of tail square
(1 genus, 2 species)

Family PTILOGONATIDAE Phainopeplas

With ten primaries, the first less than two thirds the sec-



VARIOUS TYPES OF FEET

ond; tarsus scaled before and with an almost bare ridge behind; beak narrow, slightly notched near tip; nostrils exposed; head crested; tail long and fan-shaped
(1 genus, 1 species)

Family LANIIDAE Shrikes
Usually with ten primaries, the first less than two-thirds the second; tarsus scaled before and with an almost bare ridge behind; beak notched and hooked at tip; nostrils almost concealed by tufts of tiny, bristly feathers, which project forward over them; tail feathers graduated; moderate-sized birds; grayish, with a black band across the eyes
(1 genus, 2 species)

Family STURNIDAE Starlings
First primary very short; second primary the longest; beak straight and wide at base; tail short and square; blackish, often light-spotted birds, about the size of a robin
(1 genus , 1 species introduced from Europe)
(1 genus, 1 species introduced from Asia)

Family VIREONIDAE Vireos
With or without a small first primary; if with nine primaries, then with the first two almost equal in length; tarsus scaled before and with an almost bare ridge behind; beak slightly notched and hooked at tip; usually with bristles at the base of the beak; basal segments of toes usually united; inner toe usually very short; end of tail square; small, greenish birds
(1 genus, 12 species)

Family COMPSOTHLYPIDAE Wood Warblers
With nine primaries, the first two almost equal in length; tarsus scaled before and with an almost bare ridge behind; beak usually slender, almost cylindrical, not notched or hooked; end of tail usually square; small birds, usually with yellow in the plumage
(16 genera, 53 species)

Family PLOCEIDAE Weaver Finches (House sparrows)
European sparrows; introduced species strongly resembling the *Fringillidae* or native sparrows
(1 genus, 2 species)

Family ICTERIDAE Blackbirds, Orioles and Meadowlarks
With nine primaries, the first two almost equal in length; tarsus scaled before and with an almost bare ridge behind; beak usually about as long as the head, not notched or

hooked; base of upper bill extending back to divide feathers of forehead; no bristles at the base of the beak; tail usually graduated; birds approaching the size of a robin
(10 genera, 18 species)

Family THRAUPIDAE Tanagers
With nine primaries, the first two almost equal in length; tarsus scaled before and with an almost bare ridge behind; beak stout; with a small projection from the middle of each side of the upper bill; nostrils exposed; end of tail square; males more or less red; females usually greenish or yellowish; moderate-sized birds
(1 genus, 4 species)

Family FRINGILLIDAE Sparrows, Finches, Buntings, Grosbeaks and Crossbills
With nine primaries, the first two almost equal in length; tarsus scaled before and with an almost bare ridge behind; beak short and stout, with smooth edges, sometimes curved or crossed; nostrils almost concealed by tufts of tiny, bristly feathers, which project forward over them; birds about the size of the house sparrow
(34 genera, 83 species)

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The names of the families used in the bird classification are those given in the fourth (1931) Check List of the American Ornithologists' Union.

MAMMALS

CHAPTER 15

In common speech the mammals are usually referred to as "animals", a general term which should include all living creatures except plants. The mammals have felt the strain of competition with man more keenly than have most of the other animals, so that the larger ones have lost out in the struggle and have either become extinct or have their ranges much restricted. Most of the smaller mammals have adjusted their lives to man's presence and by extreme wariness or nocturnal or crepuscular habits have managed to survive. Wherever a bit of wild country remains, unfit for agriculture but suitable for animal breeding grounds, the smaller mammals remain. A brier patch, a swamp or a rocky hillside, even on the outskirts of a city, may be a haven of refuge. Studies have shown that in the vicinity of Chicago thirty-nine species of wild mammals still survive and that around Northampton, Massachusetts, after almost three hundred years of settlement, thirty-five species yet remain. It is to be hoped that more of our waste and otherwise worthless lands may be set aside as true sanctuaries for all forms of wild animal life.

The native mammals are divided into seven main groups. Taxonomically speaking, the first and "lowest" in the list of our mammals is the opossum. It is the only North American representative of the *Marsupialia,* mammals that produce their young in a very early stage and let them finish their development in an abdominal pouch or marsupium. The *Xenarthra* or American edentates are represented in the United States by only one species, the nine-banded armadillo, found along the Mexican border. It is characterized by unspecialized teeth and a strange bony covering or shell. The *Chiroptera* or bats are widely distributed. They were at one time placed at the head of the class *Mammalia,* because they are the only vertebrates, other than birds, that can truly fly. The *Artiodactyla,* ungulates or hoofed animals, include the peccary, cattle, deer and pronghorn antelope. The cattle family, of which the bison, bighorn sheep and mountain goat are representatives, have horns—unbranched, permanent structures present in both sexes and consisting of bony cores covered with thin material called horn. The deer have solid, branched structures called antlers, which develop only in the male in all native deer except the caribou and which are shed annually. The pronghorn antelope stands alone in having singly branched horns the outer layers of which are shed each year — apparently a halfway stage between antlers and horns. The *Rodentia* or gnawing animals are the largest group of mammals. Here belong rats, mice, squirrels, woodchucks, beaver, chipmunks and gophers. Rabbits (*Lagomorpha*) are often included in this group, although they differ from the rest in having two tiny teeth set directly behind the two large upper incisors. The members of this group are very difficult to identify, as distinguishing characters are based on skull and tooth distinctions, differences in proportion and shades of coat coloring. The *Insectivora* are probably the least familiar group. Here belong the moles, animals adapted for underground life by short fur that lies smooth when brushed either way, fore limbs widened and shortened, hands enlarged for digging, and eyes reduced to the size of pin-heads and covered with thin skin — and the shrews, which look like velvety-haired, short-tailed mice but differ from mice in dentition. The *Carnivora* include the foxes, wolves, cats, bears, raccoons and ring-tailed cat, and the weasels. Some of these are almost entirely carnivorous, while others have become adapted to a more varied diet. These habits are interestingly correlated with the form of the cheek teeth. In the more strictly carnivorous forms the last premolar or the first molar is of the sectorial or carnassial type, with a sharp edge and flattened side, and engages a similarly modified tooth in a shearing action. In more omnivorous forms, such as the raccoon, these teeth have become broader and serve for crushing or grinding rather than shearing. In still more omnivorous forms, such as the bears, fond of insects and berries, the molars are definitely of the grinding type and the premolars are quite small and often shed. Although outside the range of this book, the seals (*Pinnipedia*) may be mentioned as an extreme example of tooth change. Their fish-eating habits have permitted a decided modification in cheek teeth, which are small and often each with three points or cusps, a character usually regarded as primitive, since it is common in fossil forms. In fact one order of extinct mammals has received the scientific name of *Triconodonta*.

The problems of the distribution of mammals and the factors governing scarcity or abundance make an interesting ecological study. Most of the larger mammals or those sought by man for fur, food or sport are being rapidly killed off except as laws providing for regulation or restriction of hunting and trapping prevent total extermination. Deer, for example, would long since have become extinct were it not for closed seasons and other hunting restrictions. At present the Virginia deer is increasing its numbers in some sections of the country under regulated control of hunting. The opossum is one of the few mammals that is extending its range in spite of apparent handicaps of small brain and little protection. Every few years it is reported from points farther and farther north; since its introduction into California several years ago, it has increased its numbers prodigiously. In general, the mammals of the greatest abundance and widest distribution are those that are adaptable in food habits. Animals of omnivorous diet, such as most of the rodents, are usually plentiful. The muskrat dines on succulent water plants and on tough, fresh-water clams with equal readiness, with an occasional frog or fish to vary the bill of fare. Chipmunks and ground squirrels may live largely on grasshoppers during the summer and lay up seeds for the fall and spring. It is common knowledge that the house mouse and the Norway rat eat any food that their human landlords may have on hand. Most of the carnivores are restricted in their diet, but a few either live mainly on insects or else have a more varied bill of fare, so that they can spread more widely than most of their group. The skunk is one of those that is mainly insectivorous and is therefore not as dependent upon its surroundings as are the weasels, its close relatives. Coyotes feed largely on mice, rabbits and carrion and fill a useful part in nature's program. Foxes, like dogs, have a varied diet, including considerable vegetable material. Both coyotes and foxes have had their undesirable qualities stressed and their desirable ones ignored by people who wish to justify poisoning or exploitation. The insectivores and the bats are widely distributed on account of their insect-eating habits. The factors governing the range of the latter are of great interest to the ecologist, as their power of flight and the fact that their food is generally distributed make them independent of the barriers that limit the distribution of the other mammals.

Problems of mammal coloration have long interested naturalists. As a general rule, large wild mammals are one color all over, and that color is usually agouti or some shade of brown. Since the world war led to the almost universal adoption of olive drab for field uniforms, the reason for the survival of mammals similarly colored and the elimination of other patterns and colors has become evident. Only when protected or domesticated by man can the conspicuous animals survive. In the semi-domesticated, Alaskan reindeer herds, white and partially white animals are becoming fairly numerous. Just as the woodland and grassland mammals must be brownish in order to survive, so in the arctic the white mammals may have been picked by natural selection, since arctic bears, foxes, wolves and rabbits are all white. An alternate theory, however, is that pigment is developed in response to, and as a protection from, bright light, and that the arctic mammals, not being subjected to intense light, are not stimulated to produce pigment. This theory is also used to explain the lack of pigment in some cave animals. Various environmental factors have been considered responsible for variation in color, but attempts to prove this have seldom been conclusive. Some interesting studies have been made on mammals of some of the southwest desert areas, where white sand and black lava offer the utmost possible contrast. In general it appears that where predators are common the isolated rodent groups tend to match the background upon which they live. Also, as a general rule, light color phases usually occur on a light colored habitat, such as sandy islands and dunes, with apparently little correlation between light or dark color and the other factors of the environment. Since these mammals produce similarly colored offspring, even when conditions are changed, it would seem that the theory of natural selection in an isolated population remains the most logical explanation for their color. A few of the mammals, such as the snowshoe rabbit or varying hare and some of the weasels, adopt white for winter wear among the snows and brown for the rest of the year. Some of the woodland mammals have white markings which were formerly regarded as warning but which now are generally considered protective. The white tail of running rabbit or deer looks most conspicuous to man from his elevated viewpoint, but to the crouching weasel or wolf the white patch blends with the sky and makes the animal a much more difficult target. The broad white stripes of the skunk may also be concealing coloration as far as the hunted mice or hunting owls are concerned. The naturalist who has attempted to trail a skunk during its early spring wanderings in search of a mate can testify that at dusk among patches of unmelted snow the skunk has most concealing coloration. Occasionally a wild mammal lacks the hereditary factors for color and is an albino, white with pink eyes. Such an animal, hampered by the usually associated physical handicaps, generally soon falls a victim to its enemies. Occasionally only part of the factors for color are lacking or changed so that the animal may be black or reddish. The common red fox occasionally produces a few black or silver offspring in this way. The black and silver foxes of our fur farms are usually different species from Alaska or northeastern Canada.

Some mammals have solved the problem of winter food scarcity by hibernation or an approach to that condition. In this peculiar and little understood condition the mammal loses control of body temperature and assumes a temperature near that of the surroundings. Its respiration and circulation become very slow, its eyes sunken, its lips lax, and it has all the appearances of being dead, except for an occasional quiver. Its food requirements are reduced to a minimum, its body fat serving to maintain it. Strictly speaking, only a warm-blooded animal can hibernate, and very few of them do so completely. The term hibernation is commonly used, however, to refer to the state of torpor in which many animals, including many of the cold-blooded ones, pass the winter. Marmots, the jumping mice, and the true ground squirrels are apparently the most profound hibernators, while some of their close relatives show no indication of such ability. Bears, badgers and raccoons usually pass the winter in a state of partial hibernation, although in the southern parts of their ranges this may be much shortened or omitted. Many other mammals store up food or fat and remain denned up for the coldest part of the winter. Among the regular hibernators there is much variation, the male often retiring for a shorter season than the female. An occasional individual may remain active all winter. Some of the ground squirrels have developed the power of entering this condition of suspended animation during the hottest months of the year also, when their food supply is cut off by the drought. Their chemical processes at this time are not slowed down as much as in the winter, so that more food material is exhausted. The animals may lose as much weight in two or three weeks summer sleep or aestivation as they do in three months hibernation.

Unfortunately we know very little about the family life of most of the wild mammals. The actions of caged animals are seldom characteristic, any more than those of a small boy in Sunday school represent his normal, unrestrained, outdoor activities. Hunters and trappers have been our best source of information, but they too often lack the scientific attitude and, like some nature writers, assign all kinds of human attributes and mental processes to the animals. The beaver has come in for a large share of attention because of its tree-felling exploits and remarkable ability to construct dams. The huge house of logs and mud, which freezes to form an impenetrable fortress when the ice-covered lake might make it accessible to lynx or wolf, is an amazing structure. The ubiquitous muskrat, although it builds no dams, has adopted a similar style of architecture, and its conical houses are common landmarks on the marshes. Wherever a steep river bank is available, however, the muskrat prefers to construct a series of burrows with under-water exits, even digging channels in the stream bed, if necessary, to make these burrows accessible at all times. The otter also digs burrows with under-water openings. Most of the rodents make burrows, many constructing an elaborate series of chambers for bedroom, storage, and other purposes. A few mice make temporary homes by building roofs on abandoned bird nests. The squirrels go them one better by building complete summer homes of leaves and twigs in the tree tops, in addition to their winter homes in hollow trees. Some of the carnivores and a few of the rodents have dens in caves, in rock crevices and similar places. Such homes are typical of bear, raccoon, porcupine and others.

Knowledge of mating habits and reproduction in wild mammals is still scanty. Such evident sexual distinctions as the antlers of the male deer, which reach their full development at the time of mating and fall off in the spring when they might injure the young or the nursing mothers, are well known. The tendency of such normally solitary or subterranean animals as the moles and the pocket gophers to wander about above ground during the breeding season in search of companions has also been observed. The larger mammals, having fairly long gestation periods, usually mate in the autumn, the young thus being born in the spring when the food supply is at its maximum and unfavorable weather as far off as possible. The most peculiar adaptation occurs in the case of bears, since the young, usually two in number, are born in the early spring while the mother is presumably still in hibernation. Possibly because they are secure in the den and are free to feed and grow without interruption for some time after birth, the young are born when very small.

A newborn bear cub is actually smaller than a newborn porcupine. The offspring of a two hundred and fifty pound black bear mother may weigh only nine or ten ounces at birth. According to Seton the bear commonly suckles her young throughout the summer and therefore usually breeds every other year. The smaller mammals usually mate early in the year, their short gestation periods enabling their young, like those of the larger mammals, to be born when living conditions are near the optimum. Thus foxes, with a gestation period of fifty days, usually mate in February, when one may often find their tracks making a network in the snow along woodland paths. The ground squirrels emerge from hibernation about the time that succulent vegetation first appears and mate even before making up for their winter's fast. It has been suggested that the development of their sexual glands may be the stimulus that arouses them from hibernation. A few of the small mammals, such as mice and rabbits, may have two or three broods a year. The opossum, the only North American marsupial, may also have two broods a year. Its young are born in a very immature condition and complete their development in a pouch covering the mammary glands. The armadillo, the only native edentate, normally has four identical young at one time, all derived from the same fertilized egg. Many of the mammals seem to be monogamous, a few, like the deer, practicing polygamy. As to whether the same pair mates in successive years or whether new mates are chosen each season, very little is yet known. In many cases the male continues his association with his mate after the breeding season and aids in the care and feeding of the young. Sometimes the association persists over a year, and family groups of the two parents and several almost grown young may be seen, as with the coyotes. Some animals, like the timber wolves, rejoin in a pack as soon as the young are big enough to play their part in the hunt. Some mammals, although not especially sociable, tend to form groups, possibly because the young merely move over to the edge of their parents' domain when they set up their own homes. Striped ground squirrels may be quite numerous in certain old pastures or cemeteries in the middle west, and on the great plains prairie dog "towns" of great extent have been described. One continuous colony two hundred and fifty miles long and one hundred miles wide is recorded in southwestern Texas, and seven thousand, two hundred burrows covering about one square mile have been counted in eastern Arizona. In general, young carnivores are likely to scatter far more widely, when the family breaks up, than are young herbivores. Probably the degree of social life is quite dependent upon the amount of competition for food.

Several little known branches of mammal study are of interest. Examinations of individual hairs under the microscope show surprising differences, especially after they are cleared by several hours immersion in xylol or other clearing fluids. A few hairs found at the mouth of a burrow or entrance to a cave or hollow tree may thus reveal the identity of the occupant. This method has also been applied with interesting results to the contents of fish and other animal stomachs. It is necessary to build up a check or sample collection of known hairs with which to compare the unknown. An interesting and well illustrated account of this study has been published by L. A. Hausman in the *American Naturalist* for 1920 (Vol. 54; Pg. 496-523).

E. T. Seton has called attention in several of his publications to the value of the droppings or "scats" as an index to animal life. Anyone who has collected around a pond or marsh frequented by muskrats has undoubtedly noticed the small piles of oval pellets left at convenient landing or feeding stations. The spherical scats of the rabbit are often the only sign to betray its "form" or grass shelter. The study of tracks is also of much aid to the naturalist as an announcement of the kinds and numbers of wild mammals of a vicinity and is treated in some detail in another chapter.

Mammals are frequently kept as pets, but the range of choice is limited, except for parks and zoos, by size, food habits, disposition and other considerations. The hoofed animals, for example, are out of the question for the average individual because of the space they require and the amount of food they consume. The opossum does not make a good pet because of its sullen disposition. Moles and shrews are generally impossible because of their enormous appetites. A mole or a shrew will eat its own weight in food in twenty-four hours. Many carnivores are prohibited by the nature of their food and by their dispositions. A few, however, make excellent pets. Among these is the much maligned skunk. Contrary to general impression the skunk rarely uses its powerful gas defense unless injured or much alarmed. In captivity it makes a docile pet and eats almost anything from hens eggs to table scraps. Some people prefer to have the scent glands of the skunk removed, before keeping it for a pet. This operation is not very difficult, if performed while the skunk is young. The raccoon group, consisting of the generally distributed raccoon and the ring-tailed cat of the southwest, are attractive animals and make interesting but mischievous pets. Perhaps the most popular pets are rodents and related forms, such as squirrels, rabbits, mice and others. These usually do well in captivity, if given plenty of opportunity for exercise. A few of the rodents cannot be kept together in cages without fatal results. Striped ground squirrels, for example, in spite of their gentle expressions, are vicious toward each other and should be caged separately. The porcupine, contrary to popular belief, cannot shoot its quills and is easily tamed. The bats are usually abhorred because of traditions of human parasites and desire to entangle themselves in human hair. The former idea is entirely erroneous; bats do not carry bedbugs or human lice but, like all animals that live in caves or hollow trees, may have external parasites of their own. The latter idea apparently arose from the fact that a bat has such mastery of flight that it does not trouble to swerve until it is almost upon an object, so that at times it appears to be coming directly at one. "Blind as a bat" is a poor figure of speech, for bats have small but fully functional eyes. If plenty of space and insect food are available, one or two bats make interesting pets and soon learn to take moths or grubs from the keeper's fingers. They must be given opportunity for flying exercises, to remain healthy. If their keeper has keen ears, he may be able to distinguish the very high-pitched squeaking they make as they fly, and which, bouncing back to their highly specialized ears, enables them to avoid obstructions. This use of "sonar" has been demonstrated at the Massachusetts Institute of Technology, where the sounds have been electrically transformed into lower tones more audible to human ears.

Few people realize that each year the United States still produces millions of dollars worth of valuable furs. The beaver, the demand for whose beautiful and durable fur was one of the factors leading to the settlement of North America, has unfortunately been extremely reduced in numbers, but its little brother, the muskrat, has taken its place as America's most valuable fur bearer. Mink, weasel, skunk, fox, raccoon and others all help swell the total. Unfortunately there has often been antagonism and distrust between trapper and naturalist. The upset in the balance of nature in cases where well-meaning but poorly informed voters have practically prohibited trapping has shown that the trapper plays a useful part, taking the place once occupied by wolf, wildcat, eagle and hawk. The cruelty of steel traps has been considerably over-emphasized. If traps of the right sizes are used, properly attached so that an animal's first jump does not bring it up with a jerk, and if traps are visited each morning and evening, there is a minimum of suffering. Also it should be remembered that, with the exception of the muskrat (and even it enjoys clams and fish), all of our best fur bearers are carnivores, which, if not kept in check, will multiply sufficiently to bring many other mammals and birds to the point of extinction. The regulation of trapping should be undertaken on the advice of game wardens and field zoologists, whose training enables them to see the practical solutions, rather than on the opinions of sentimentalists or those who may profit by the exploitation of wild life.

It is highly desirable that every naturalist should know how to make up a study skin of a mammal. Sometimes rare or unusual material comes to him unexpectedly and valuable specimens may spoil unless given prompt attention. A study skin is the coat of a mammal preserved and poisoned against insect pests and filled out to approximately its normal size and contours. The work is easily learned and, if desired, the mammal may later be mounted in a lifelike attitude by a professional taxidermist. Before skinning the animal at least two careful measurements should be made, of (1) *total length*—

length in a straight line from tip of nose to end of tail vertebrae, not to the end of the hair, and (2) *length of tail,* from root to end of last vertebra. The *length of hind foot,* from heel to end of longest toe, is often made, although sometimes it is measured to the tip of the longest claw. Directions for making up skins may be found in any good handbook of taxidermy or in an inexpensive bulletin sold by the American Museum of Natural History in New York City. The skull, cleaned by gentle boiling, should always be preserved and any loose bones or teeth glued in with Duco cement or a glue of celluloid scraps dissolved in acetone. In all cases the skull and skin should each bear a number corresponding to a record entry of the name, sex, habitat and date of capture.

The naturalist learns to identify mammals by their bones, especially by their skulls, as well as by other characters. Quite often only the bones are available, as when animals have died in fields, woods, or caves and have been long exposed. Frequently the den of some wild carnivore contains bones, and we wish to know just what the prey was. Owl pellets — the masses of regurgitated hair and bones of previous meals — often tell more about the small local mammals than could be learned by several nights of trapping. Even fish stomachs sometimes contain identifiable mammal bones. As an aid to this study a key to mammal skulls follows the mammal key, and a few pointers are given here.

Mammal skulls differ from those of other animals in the large brain case and, except for the armadillo, heterodont dentition or specialization of teeth. They share with the amphibians the possession of two occipital condyles, the processes which articulate the skull with the first segment of the backbone, but differ from amphibians in the high, rounded cranium or brain case. In the introductory chapter will be found a key by which the skulls of the groups below mammals may usually be recognized.

TEETH

The teeth furnish the most important clue to identity. If a skull is found, care should be taken to gather as many of the teeth as possible and to avoid dislodging them from their sockets. If a skull is cleaned, the teeth should be cemented into place as soon as they loosen. If the teeth are missing, their sockets are of some aid, and identification is still possible. The arrangement is a clue to the orders. The front teeth are the incisors or cutting teeth. In carnivores they are small in proportion to the other teeth. In rodents they are very long, and often curve in almost a semicircle within the bones. In rabbits, hares and pikas the upper pair have a minute pair directly behind them. In the deer, antelope and cattle families there are no upper incisors, merely a ridge of bone against which the lower teeth hold the grass or twigs while they are torn away. Most native bats have a gap in the front of the upper jaw, with one or two minute incisors on each side of it. On either side of the incisors come the canines, never more than one in each quarter. These are holding or stabbing teeth, long in carnivores, much reduced or lacking in herbivores, and never present in rodents. Following these come the cheek teeth or grinders, technically divided into premolars and molars, but the distinction frequently not apparent. Their number and surface are important clues to the identity of their owners. In carnivores they are frequently modified into cutting instruments, food being bolted in chunks without chewing. In grass, twig and grain eaters the enamel is often infolded to create a series of ridges like those on a lower millstone. In the even-toed hoofed mammals these folds usually form a crescentic pattern; in rodents they may form a complicated series of loops and triangles. The tooth formula is usually given for half the upper and half the lower jaw. Thus 2/2 . 1/1 . 2/2 . 3/4 would mean that the animal had thirty-four teeth altogether or two incisors, one canine, two premolars and three molars above on each side; and the same, but for an additional molar, on each side of the lower jaw.

SKULL CHARACTERS

These are illustrated, and the beginner is advised to take a skull, such as that of a dog, and learn the arrangement of the bones. This arrangement is remarkably constant, although the relative proportions vary greatly. Special notice should be given to the *nasal-lacrimal-maxillary* area, which varies much in different members of the hoofed animals; the *post-orbital process* and *ante-orbital opening,* which are of special value in keying rodent skulls; the *zygomatic bar* or arch below the eye region, and, on the underside, the *bulla* or swelling below the ear region. It should be kept in mind that the *orbit* or eye-socket is seldom partitioned off from the *temporal fossa,* through which the muscles and the ascending process from the lower jaw pass to the side or top of the cranium. The orbit, however, lies largely before the brain case and is bounded posteriorly by a group of openings or foramina through which nerves pass from the brain to the eye.

OUTLINE OF CLASSIFICATION OF NATIVE MAMMALS

Class MAMMALIA

Order MARSUPIALIA

Young born at an early stage of development, usually completing development in parent's abdominal pouch; epipubic bones present; palate with large fenestrations; inner angle of lower jaw inflected

Family DIDELPHIIDAE Opossums

With ten incisor teeth in upper jaw; eight in lower; tail naked and prehensile

One genus — *Didelphis*

Order INSECTIVORA

Small animals with complete dentition, teeth sharp-pointed, snout extending beyond mouth

Family TALPIDAE Moles

Arm very short; hand broad, adapted for burrowing; eyes minute, concealed in fur

Five genera — *Scalopus*
Scapanus
Parascalops
Condylura
Neürotrichus

Family SORICIDAE Shrews

Form mouse-like, but with complete dentition; teeth reddish; snout overhanging mouth

Six genera — *Sorex*
Neosorex
Microsorex
Cryptotis
Blarina
Notiosorex

Order CHIROPTERA Bats

Mouse-like head and body; fingers elongated to support a membranous wing

Family PHYLLOSTOMIDAE Leaf-nosed Bats

With an upright leaf-like growth on nose

One genus—*Macrotus*

Family VESPERTILIONIDAE

No leaf-like growth on nose; tail included nearly to tip in membrane

Ten genera — *Myotis*
Lasionycteris
Pipistrellus
Eptesicus
Lasiurus
Dasypterus
Nycticeius
Euderma
Corynorhinus
Antrozous

Family MOLOSSIDAE

No nose leaf; at least one-half of tail not included in membrane

Two genera — *Tadarida*
Eumops

Order CARNIVORA Carnivores

Incisors small and canines long; first molars or last premolars usually modified for shearing or cutting

Family URSIDAE Bears

Largest carnivores; tail very short; no specialized carnassial teeth; molars with flattened crushing surfaces

One genus — *Ursus*

Family PROCYONIDAE Raccoons

Bushy tail, with black rings

Two genera — *Procyon*
Bassariscus

Family MUSTELIDAE

Small to medium sized carnivores, with long skulls, the orbit definitely before the middle; anal glands usually developed

Subfamily MUSTELINAE Martens, Weasels and Minks

Short-limbed and long-bodied; feet not webbed

Two genera — *Martes*
Mustela

Subfamily GULONINAE Wolverines

Form bear-like, stout

One genus — *Gulo*

Subfamily LUTRINAE Otters

Feet well webbed; tail long, tapering and short-haired

One genus — *Lutra*

Subfamily ENHYDRINAE Sea-otter

Feet well webbed; tail moderately short (Not included in the general Mammal Key)

One genus — *Enhydra*

Subfamily MEPHITINAE Skunks

Anal scent glands well developed; tail long and bushy; with a conspicuous black and white pattern

Three genera — *Spilogale*
Mephitis
Conepatus

Subfamily TAXIDIINAE Badgers

Legs very short; body wide and flattened; fingers with very long claws

One genus — *Taxidea*

Family CANIDAE Wolves, Coyotes, Foxes

Dog-like, tail bushy; claws not retractile; four digits (on each foot) reaching ground

Three genera — *Vulpes*

Urocyon

Canis

Family FELIDAE Cats

Head rounded; tail long or short, well haired, but not bushy; claws retractile; four digits (on each foot) reaching ground

Two genera — *Felis*

Lynx

Order PINNIPEDIA (Not included in the general Mammal Key)

Marine carnivores, with legs modified into paddle-like structures

Family OTARIIDAE Eared Seals, Sea-lions

Hind limbs capable of rotation; with small external ears

Three genera — *Zalophus*

Eumetopias

Callorhinus

Family PHOCIDAE Hair Seals

Hind limbs incapable of rotation; no external ears

Three genera — *Phoca*

Cystophora

Mirounga (Almost extinct)

Order RODENTIA Rodents

Without canine teeth; incisors two above and two below, long and without roots; with a wide gap between incisors and cheek teeth

Family SCIURIDAE Marmots, Ground Squirrels, Prairie-dogs, Chipmunks and Squirrels

Squirrel-like; tail well haired; head rounded; skull with definite post-orbital processes

Eight genera — *Marmota*

Citellus

Cynomys

Eutamias

Tamias

Sciurus

Tamiasciurus

Glaucomys

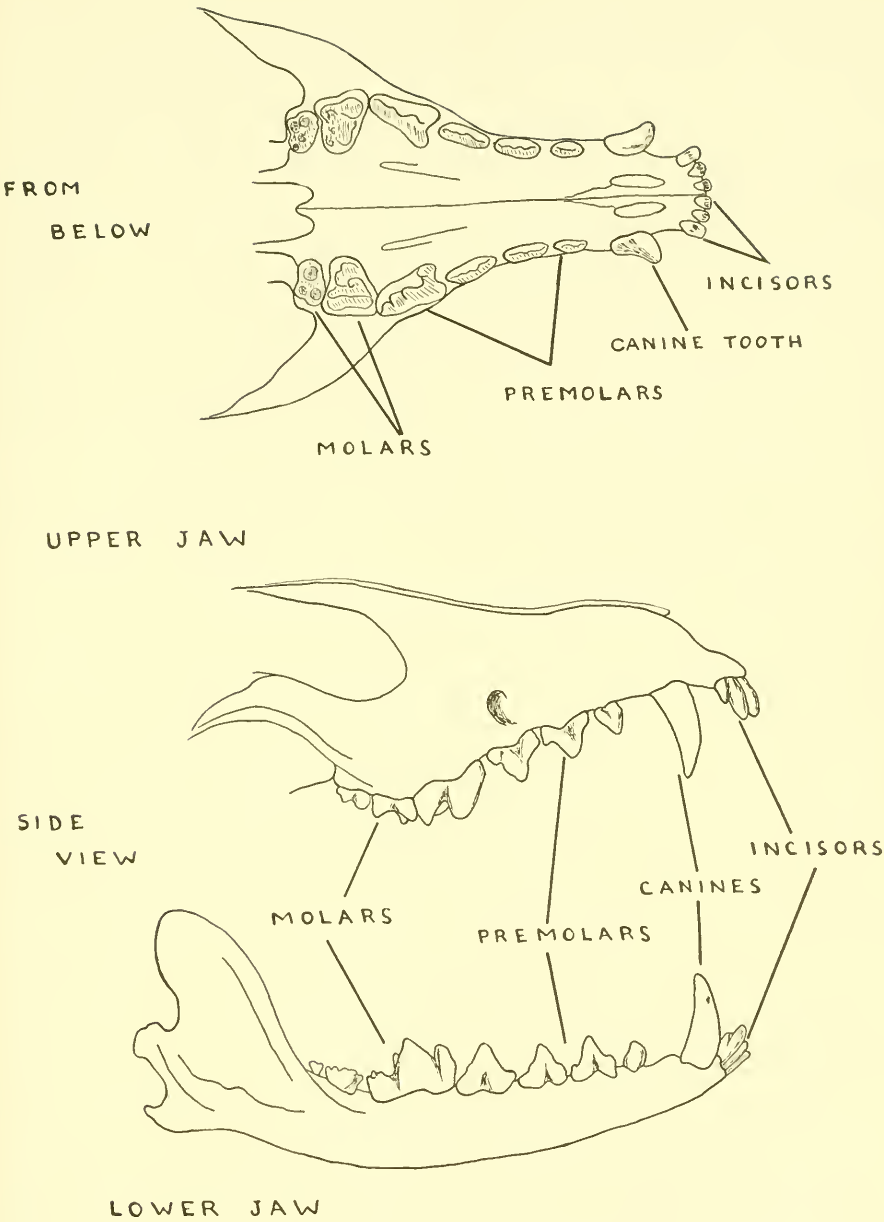
Family GEOMYIDAE Pocket Gophers

With fur-lined cheek pouches; animal adapted for burrowing; limbs, ears and tail short; fore feet with greatly developed claws

Three genera — *Thomomys*

Geomys

Cratogeomys



THE TEETH OF A CARNIVORE

Family HETEROMYIDAE Pocket Rats and Pocket Mice

With fur-lined cheek pouches; animals adapted for jumping; with long hind legs and tail

Four genera — *Liomys*
Perognathus
Dipodomys
Microdipodops

Family CASTORIDAE Beavers

Tail broad, flat, scaly; hind feet large and well webbed; claw of second toe split

One genus — *Castor*

Family CRICETIDAE Native Rats and Mice

Mouse or rat form; tail scaly but with hairs; not more than three cheek teeth on each side

Subfamily CRICETINAE

Molar teeth with tubercles in two rows or with enamel folds not forming more than three loops on any tooth

Seven genera — *Onychomys*
Reithrodontomys
Baiomys
Peromyscus
Oryzomys
Sigmodon
Neotoma

Subfamily MICROTINAE

Molars flat-crowned, usually with angular infoldings of enamel forming several loops or triangles on each tooth

Eight genera — *Synaptomys*
Phenacomys
Evotomys
Microtus
Lagurus
Pitymys
Neofiber
Ondatra

Family MURIDAE Old World Rats and Mice

Mouse or rat form; tail scaly, almost naked; molars with three rows of tubercles

Two genera — *Mus*
Rattus

Family APLODONTIIDAE Mountain Beaver

Guinea pig appearance; molars plane, without infoldings of enamel on grinding surface

One genus — *Aplodontia*

Family ZAPODIDAE Jumping Mice

With elongate hind legs and tail; upper incisors grooved in front

Two genera — *Zapus*
Napaeozapus

Family ERETHIZONTIDAE Porcupines

Hairs coarse, with some thickened to form quills; with four fingers and five toes on each side; ears short

One genus — *Erethizon*

Order LAGOMORPHA Rabbits, Hares, Pikas

Much like rodents, but with a pair of small incisor teeth behind the large upper pair

Family OCHOTONIDAE Pikas

No external tail; hind legs scarcely longer than fore legs

One genus — *Ochotona*

Family LEPORIDAE Hares and Rabbits

With a short tail; hind legs elongate

Two genera — *Lepus*
Sylvilagus

Order ARTIODACTYLA

Even-toed hoofed mammals

Family TAYASSUIDAE Peccaries

Pig-like, but almost tailless; upper canines pointing downwards, and with four upper incisors

One genus — *Pecari*

Family CERVIDAE Deer

Males with solid antlers, shed annually, growing from permanent bases on the frontal bones; second and fifth toes present

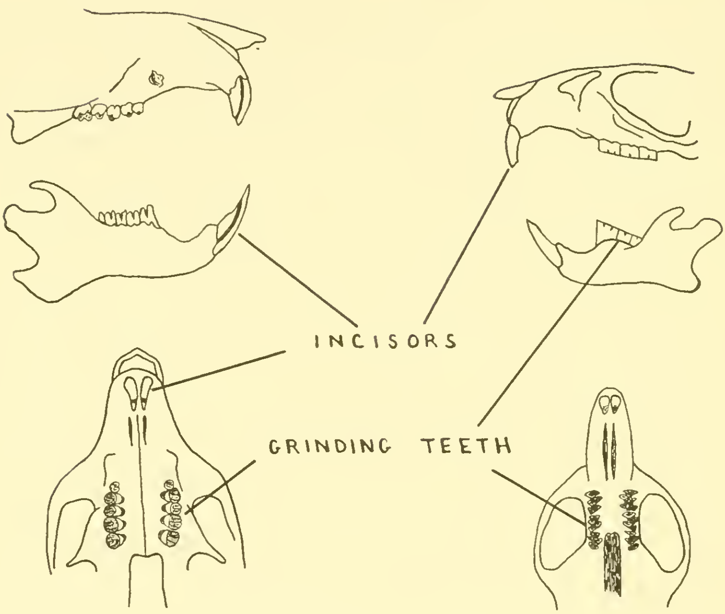
Four genera — *Cervus*
Odocoileus
Alce
Rangifer

Family ANTILOCAPRIDAE Pronghorn

Both sexes with deciduous, one-branched horns on permanent, unbranched cores; orbit below horn

One genus — *Antilocapra*

INSECTIVORE TEETH



WITH TUBERCULATE MOLARS AND GROOVED INCISORS

WITH FLATTENED MOLARS AND UNGROOVED INCISORS

TEETH OF A GNAWING ANIMAL

Family BOVIDAE Cattle, Sheep, Antelopes, Goats

Both sexes usually with permanent, hollow, unbranched horns on bony cores; second and fifth toes present

Three genera — *Bison*
Ovis
Oreamnos

Order XENARTHRA American Edentates

Teeth absent or imperfectly developed, without enamel, not specialized

Family DASYPODIDAE Armadillos

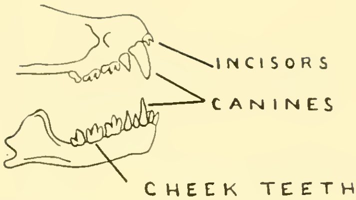
One genus — *Dasypus*

KEY TO THE PRINCIPAL LARGE GROUPS OF MAMMALS

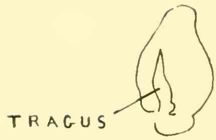
1. Fingers of each fore limb greatly elongated and supporting a leathery, membranous wing Bats
   Fingers not greatly elongated and not supporting a wing 2.
2. Feet with hoofs Ungulates or Hoofed Mammals
   Feet with claws 3.
3. Incisor teeth usually smaller than most of the other teeth; canine teeth present; no large gaps between the teeth — or else with a row of unspecialized teeth on each side of each jaw, without incisors or canines, in one species which is covered by a bony "shell" Carnivores and similar mammals.
   Incisor teeth larger than the others; no canine teeth; with a wide gap between the incisors and the cheek or grinding teeth; not more than two incisors in the lower jaw Gnawing Mammals (Rodents, etc.)

KEY TO THE PRINCIPAL SPECIES OF BATS

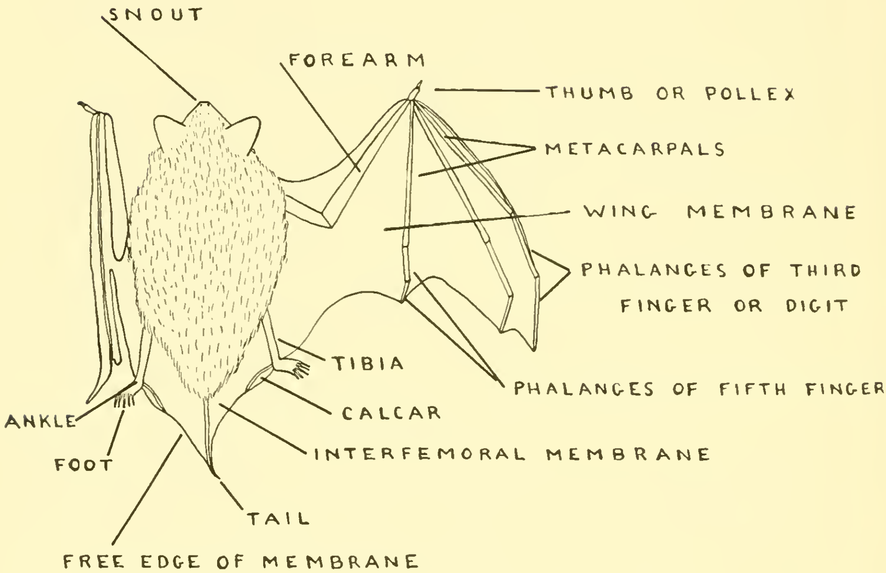
1. Ears very large, concealing the face when viewed from the dorsal side, and joined at base by a band across the forehead 2.
   Ears not usually large enough to conceal the face, never joined by a band across the forehead 6.
2. With either a leaf-like projection or a warty outgrowth on the end of the nose 3.
   Not so 5.
3. Nose with an upright, leaf-like projection; southwestern U. S. into Mexico; Family *Phyllostomidae*
   Macrotus californicus Baird Leaf-nosed Bat
   Nose with a lump-like, warty outgrowth on the end; nostrils opening upwards; Family *Vespertilionidae* (part) 4.
4. With white-tipped hairs on the abdomen; southeastern states
   Corynorhinus macrotis (Le Conte) Le Conte's Lump-nosed Bat (*Plecotus macrotis* (Le Conte))



THE TEETH



THE EAR



DORSAL VIEW OF ANIMAL

DIAGRAM OF A BAT

Hairs on abdomen not white-tipped; Pacific and southern states
Corynorhinus rafinesquii (Lesson) Rafinesque's Lump-nosed Bat
(*Plecotus rafinesquii* (Lesson))

5. Without conspicuous white spots; tail projecting well beyond the wing membrane; total length slightly over six inches; southwestern states; Family *Molossidae* (part)
Eumops perotis californicus (Merriam) Bonneted Bat
With a conspicuous white spot on each shoulder and on the rump; tail not as above; total length slightly over four inches; southwestern states; rare
Euderma maculata (Allen) Spotted Bat
(of Family *Vespertilionidae*)

6. With a stout, mouse-like tail projecting about an inch beyond the wing membrane; wings very narrow; Family *Molossidae* (part) Free-tailed Bats 7.
Tail not so; wings not very narrow; Family *Vespertilionidae* (part) 9.

7. With a prominent swelling between the eye and the nostril; recorded for states west of the Mississippi
Tadarida macrotis (Gray) Large Free-tailed Bat
(*Tadarida depressa* (Ward))
Not so 8.

8. In the southeastern states, probably to Louisiana
Tadarida cynocephala (Le Conte) Le Conte's Free-tailed Bat
In the southwestern states, Texas and Colorado westward; not differing externally from the above
Tadarida mexicana (Saussure) Mexican Free-tailed Bat
(*Molossus mexicanus* Saussure)
(*Nyctinomus nasutus* Allen)

9. Each nostril almost surrounded by a conspicuous high ridge; ears, when laid forward, extending considerably beyond the end of the snout; with four lower incisors; total length about four inches; western states
Antrozous pallidus (Le Conte) Pale Bat
Not with the preceding combination of characters; with six lower incisors; widely distributed 10.

10. Wings narrow; third finger definitely longer than fifth, and phalanges of fifth digit of equal length; with four mammae 11.
Wings wider; third finger usually only slightly longer than fifth, and phalanges of fifth finger not of equal length; with two mammae 13.

11. Large, often reaching six inches in total length; interfemoral membrane (between hind legs and tail) furred only half way down; color light yellowish-brown; southern states, westward to Texas
Dasypterus floridanus Miller Yellow Bat
(*Dasypterus intermedius* (Allen))
Smaller; adults four to five and one-half inches; if large, hair grayish at base, silvery at tips; interfemoral membrane furred nearly to the edge; generally distributed 12.

12. Total length about four inches; color usually rust-red, sometimes yellowish-gray

Lasiurus borealis (Müller) Red Bat
(*Nycteris borealis* (Müller))

Total length about five inches; color gray, with hairs of back dark at base, fading to silvery at tips

Lasiurus cinereus (Beauvois) Hoary Bat
(*Nycteris cinerea* (Beauvois))

13. Ear short and wide, with a short, broad tragus almost as wide as high; color blackish-chocolate, with some hairs white-tipped; generally distributed

Lasionycteris noctivagans (Le Conte) Silvery-haired Bat

Tragus about twice as high as wide; color not hoary 14.

14. Fur light yellowish or yellowish-gray; glandular area on each side of snout practically bare; usually less than three and one-half inches in total length 15.

Fur usually brownish, except sometimes in dry habitats; sides of muzzle with hair; usually three and one-half inches or more in length 16.

15. Tragus with widest part just below the tip, which is inclined forward; from western Texas westward

Pipistrellus hesperus (Allen) Western Pipistrelle Bat

Tragus with widest portion near base; tip not inclined forward; from the eastern states to Iowa and Texas

Pipistrellus subflavus (Cuvier) Georgian or Pipistrelle Bat

16. Profile almost straight; tragus short and blunt, curving noticeably forward; with one upper incisor on each side; west to Texas

Nycticeius humeralis (Raf.) Rafinesque's Bat

Profile of head concave ("dished in" portion can be felt with the finger tip, although the hair conceals it), or sometimes almost straight; tragus not curving decidedly forward; with two tiny incisors on each side 17.

17. Interfemoral membrane bare; hair long, usually almost half an inch on the back; getting to be four and one-half inches in total length; generally distributed

Eptesicus fuscus (Beauvois) Big Brown or House Bat
(*Vespertilio fuscus* Beauvois)

Interfemoral membrane furred about one-quarter of the way down; hair about one-quarter of an inch long; smaller; *Myotis* or Little Brown Bats (A difficult group, with many subspecies. For revision of this genus, see Miller and Allen, 1928, U. S. Nat. Museum, Bull. 144.) 18.

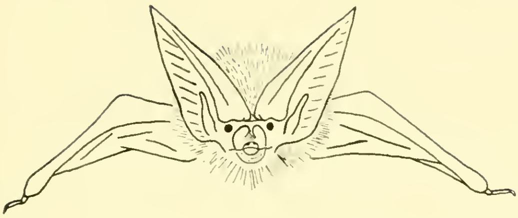
18. Hair on back of uniform color, not much darker at base; wing membrane attached at ankle; central states

Myotis grisescens Howell Cave Bat

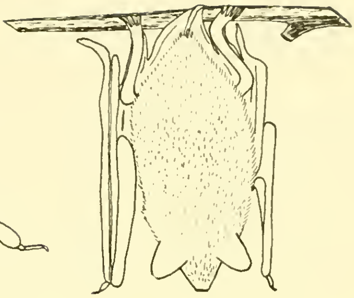
Hair on back definitely darker at base; wing membrane attached at base of toes 19.

19. Free edge of interfemoral membrane very distinctly hairy; in the western states

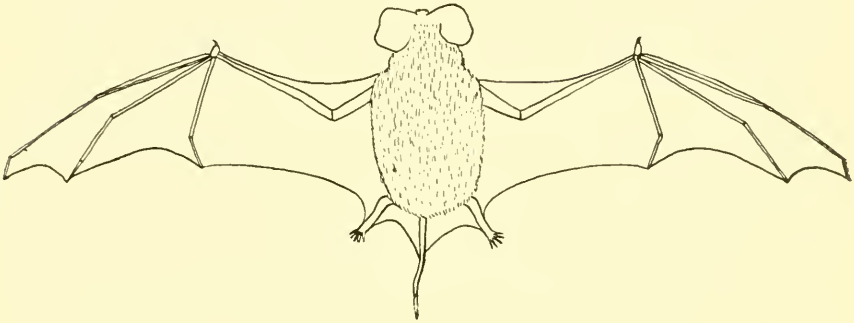
Myotis thysanodes Miller Fringed Bat



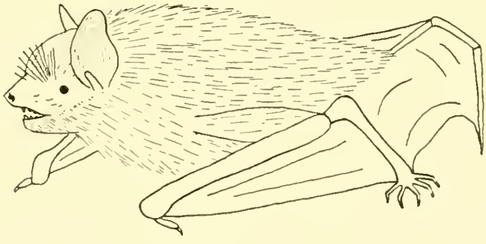
LUMP-NOSED BAT
FACE VIEW



LITTLE BROWN BAT
ASLEEP



THE FREE-TAILED BAT



BIG BROWN OR HOUSE BAT WALKING

Free edge of interfemoral membrane hairless or only very sparsely sprinkled with hairs 20.

20. Fur extending on under side of wing membrane to a line joining elbow and knee; in the western states
Myotis volans (Allen)
Fur not extending so far on under side of wings 21.

21. Ears so long as to reach one-quarter to one-half an inch beyond the nose, when laid forward; from Colorado and the Dakotas westward to the coast
Myotis evotis (Allen)
Ears reaching to, or only slightly beyond, the nose; generally distributed 22.

22. Hair of back with glossy tips, giving rather a silky or burnished appearance, when seen at the right angle 23.
Hair of back without glossy tips, but with rather a dull, woolly appearance 25.

23. Foot not half as long as tibia; third and fourth fingers usually about equal; calcar with a distinct keel; generally distributed
Myotis subulatus (Say)
(Not the *M. subulatus* of most writers, which is *M. keenii septentrionalis* (Trouessart))
Foot half, or more than half, the length of the tibia; fourth finger usually definitely shorter than the third; calcar sometimes thickened, but never with a distinct keel 24.

24. Longer hairs of back about one-third of an inch long; most of temperate United States; the most common bat in eastern United States; fairly common in the wooded areas of the western states
Myotis lucifugus (Le Conte) Little Brown Bat
Longer hairs of back only about one-fifth of an inch long; in New Mexico, Arizona and California
Myotis occultus Hollister

25. Ears, when laid forward, extending somewhat beyond nostril 26.
Ears not extending beyond nostril 27.

26. Foot small, less than one-half as long as the tibia; calcar with a distinct keel; in the western states, from the coast eastward to Utah and Colorado
Myotis californicus (Audubon and Bachman)
Foot usually one-half as long as the tibia; no definite keel on calcar; east of the Rockies and in northwestern Washington
Myotis keenii (Merriam)
(Subspecies "*septentrionalis* (Trouessart)" is the form called *M. subulatus* (Say) by many writers)

27. Hairs of back tricolor—basal two-thirds dark, then a narrow gray band, and a brown tip; calcar keeled; foot about one-half the length of the tibia; fourth finger three-fourths as long as the third; in the Mississippi Valley and eastward
Myotis sodalis Miller and Allen

Hairs of back not obviously tricolor; calcar not keeled; foot usually more than one-half the length of the tibia; fourth finger more than three-fourths the length of the third 28.

28. Occurring in the southwestern states; forearm of adult more than one and one-half inches long
Myotis velifer (Allen)
Forearm of adult not over one and one-half inches long, or else east of the Mississippi River 29.

29. In the western states; with a well developed lobe at the end of the calcar
Myotis yumanensis (Allen)
In the eastern and central states; no or a minute lobule at the end of the calcar
Myotis austroriparius (Rhoads)

KEY TO THE PRINCIPAL SPECIES OF UNGULATES OR HOOFED ANIMALS

1. Decidedly pig-like, but with a very short tail and with upper canines directed downwards; Mexican border states; Family *Tayassuidae*
Pecari angulatus (Cope) Peccary, Musk-hog
(*Tayassu angulatus* (Cope))
Not so 2.

2. Ox-like, as large as domestic cattle; both sexes with horns like those of cattle; with long hair on head and shoulders; a hump on the shoulders; formerly abundant on the plains and prairies, now restricted to game refuges and parks; Family *Bovidae* (part)
Bison bison (Linn.) Bison, Buffalo
Deer, sheep or goat-like 3.

3. Deer-like, with or without antlers 4.
Sheep-like or goat-like, horned 12.

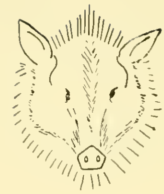
4. Antlers (really horns) almost upright directly above the eyes, each with one short front branch; whole rump covered with long white hairs, which can be erected; western states; Family *Antilocapridae*
Antilocapra americana (Ord) Pronghorn Antelope
Antlers not present or not as described above; Family *Cervidae* 5.

5. End of nose entirely covered with hair; upper canine teeth usually present; hoofs broad and flat; antlers, which may be present on either sex, somewhat flattened, palmate 6.
With a strip on the end of the nose not covered with hair; other characters various 7.

6. Color warm brown, darker on the legs; extreme northern and northeastern U. S.
Rangifer caribou caribou (Gmelin) Woodland Caribou, American Reindeer
Color blackish-brown, almost black on the legs; northern Rockies
Rangifer arcticus montanus Seton Mountain Caribou

7. With a small strip between the nostrils not covered with hair; no upper canines; antlers (of male, if present) much flattened and largely in one

VIRGINIA DEER
(MALE)



PECCARY

WAPITI OR ELK
(ADULT MALE)

VIRGINIA DEER
(FEMALE)

BISON (ADULT MALE)

plane, with sharp points projecting from the edge; Maine to Montana, and southward to Yellowstone

Alce americana (Clinton) American Moose

(*Alces americana* (Clinton))

(*Paralces americana* (Clinton))

End of nose between the nostrils without hair; with or without upper canines; antlers slender and more branched (in male only) 8.

8. With upper canine teeth; antlers, when present, curved backwards, the tines or branches arising from the front side; now restricted to the western states 9.

No upper canines; antlers, when present, curved forward, the tines arising from the back side 10.

9. Color dark above; western states

Cervus canadensis (Erxleben) Wapiti, American Elk

Color light brown; California

Cervus nannodes Merriam California Elk

10. Tail conspicuously white on the under side; tines of antlers not forked; generally distributed

Odocoileus virginianus (Boddaert) Virginia or White-tailed Deer (Many intergrading subspecies)

End of tail dark below; tines of antlers forked 11.

11. Upper part of tail white; tail half bare beneath; plains and Rocky Mountain states

Odocoileus hemionus (Raf.) Mule Deer

Upper part of tail dark; tail furred beneath; Pacific states

Odocoileus columbianus (Richardson) Black-tailed Deer (Considered to be a subspecies of the preceding)

12. Horns, which are curved slightly backwards, each with a small anterior tine or branch; outer layer of horns shed annually; no dew claws; western states; Family *Antilocapridae*

Antilocapra americana (Ord) Pronghorn Antelope

Horns unbranched, permanent; dew claws (small hoofs behind and above the principal hoofs) present; Family *Bovidae* (part) 13.

13. Chin with a beard; hair very long, whitish; with small black horns curved slightly backwards; Idaho north and west

Oreamnos americanus (Blainville) Rocky Mountain Goat (Really an antelope)

No beard on chin; hair shorter, brownish; horns of male massive, curved backwards, outwards, and around at sides of head; horns of female small and curved slightly backwards; horns of both sexes brown; New Mexico north and west

Ovis canadensis Shaw Bighorn Mountain Sheep

ROCKY MOUNTAIN GOAT

PRONGHORN ANTELOPE

BULL MOOSE

WOODLAND CARIBOU (MALE)

BIGHORN OR MOUNTAIN SHEEP (MALE)

KEY TO THE PRINCIPAL GENERA AND SPECIES OF CARNIVORES, INSECTIVORES AND SIMILAR MAMMALS

1. Mammal almost as large as a house cat, with the body completely enclosed in a bony "shell"; no incisor or canine teeth and with a row of unspecialized teeth along each side of each jaw; Texas; Family *Dasypodidae* (An Edentate)
   Dasypus novemcinctus texanus (Bailey) Armadillo
   Mammal not so enclosed; with incisors and canines 2.

2. Canine teeth not noticeably longer than, nor much different from, the others; snout long and pointed, with the upper lip projecting beyond the lower; not more than ten inches long Moles and Shrews (Insectivores) 3.
   Canine teeth considerably longer than the others; size various 29.

3. Front feet very large and wide; no external ears; total length (including tail) from five to ten inches; Family *Talpidae* Moles 4.
   Front feet not extremely large; ears present, although sometimes almost hidden in the fur; total length usually less than five inches; resembling a mouse but with a much more pointed snout; Family *Soricidae* Shrews 10.

4. End of snout surrounded by a disc of twenty-two hairless, fleshy projections; northeastern and east-central states
   Condylura cristata (Linn.) Star-nosed Mole
   No such disc at end of snout 5.

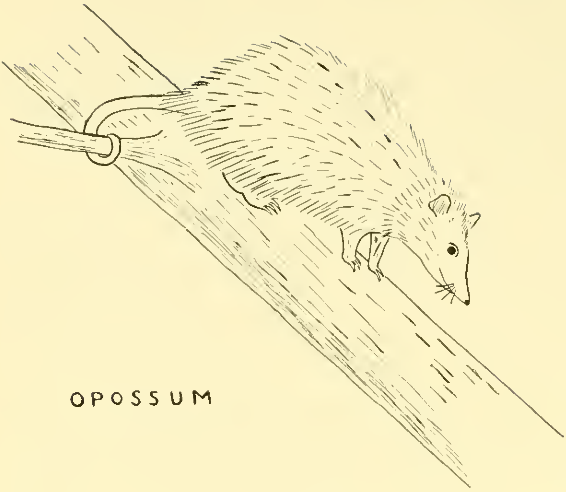
5. Palms broader than long; toes webbed; east of the Rockies
   Scalopus aquaticus (Linn.) Eastern Mole
   (A number of subspecies)
   Palms as long as or longer than broad; toes not webbed 6.

6. Total length of adult four and one-half to five inches; tail about one-third of total length; palms longer than broad; Pacific states
   Neürotrichus gibbsii (Baird) Shrew Mole
   Total length six to nine inches; tail one-fourth to one-fifth of total length; palms about as broad as long 7.

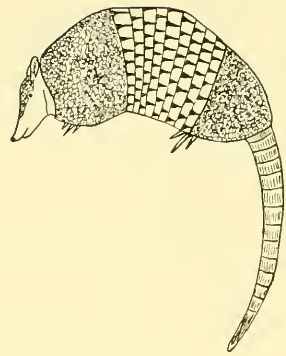
7. Nostrils opening on sides of snout; tail well haired; eastern and east-central states
   Parascalops breweri (Bachman) Hairy-tailed Mole
   Nostrils opening on top of snout; tail scarcely haired; west of Rockies 8.

8. Unicuspid teeth (cheek teeth having one point) not evenly spaced, crowded; fur brown or gray; Cal. into Nev. and Oregon
   Scapanus latimanus (Bachman) California Mole
   Unicuspid teeth evenly spaced, not crowded; fur dark, usually almost black; from northern Cal. northward 9.

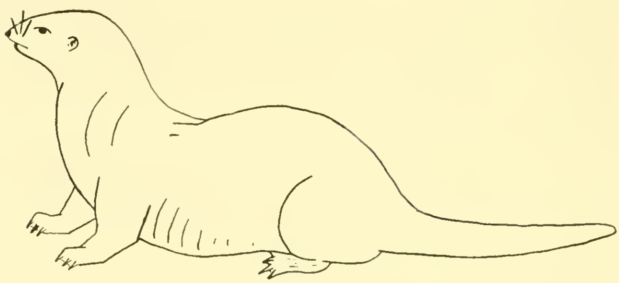
9. Length eight to nine inches; sides of cranium decidedly angular
   Scapanus townsendii (Bachman) Oregon Mole
   Length (including tail) six to seven inches; sides of cranium rounded
   Scapanus orarius True Coast Mole



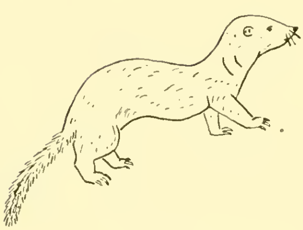
OPOSSUM



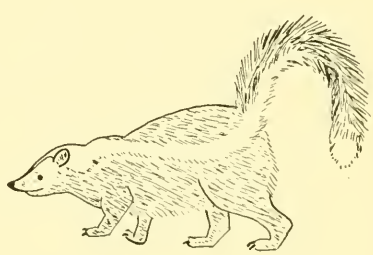
ARMADILLO



OTTER



MINK



COMMON SKUNK

10. Tail short, about one-fifth of total length; ears completely concealed by the fur; eastern states 11.
Tail longer, from one-third to one-half of total length; ears usually visible above the fur 12.

11. Total length four to five inches; with thirty-two teeth
Blarina brevicauda (Say) Short-tailed Shrew
About three inches long; only thirty teeth, some minute
Cryptotis parva (Say) Little Short-tailed Shrew (and related forms)

12. Three unicuspid teeth visible from side view of upper jaw 13.
Five unicuspid teeth, the most posterior often minute, visible from side view of upper jaw 14.

13. In the northern and north-central states
Microsorex hoyi (Baird) Pigmy Shrew
In the southwestern states
Notiosorex crawfordi (Coues) Crawford Shrew

14. Hind feet with stiff hairs between the toes, making the feet more or less paddle-like; usually over six inches long (Subgenus *Neosorex*, or genus *Neosorex* of some writers) 15.
Hind feet not heavily haired; often smaller 16.

15. Under parts scarcely lighter than upper parts; tail black above and below; Pacific coast region
Sorex bendirii (Merriam) Bendire Water Shrew
Under parts much lighter than upper parts; tail blackish above, white below; Rocky Mountain region and westward; also in the north-central states
Sorex palustris Richardson Richardson Water Shrew

16. East of the Rockies 17.
In the Rocky Mountain region and westward 22.

17. Fourth unicuspid tooth larger than the third; southeastern states
Sorex longirostris Bachman Carolina Shrew
Fourth unicuspid tooth smaller than, or rarely as large as, the third (in upper jaw) 18.

18. Total length (including tail) of adult two and one-half to four inches 19.
Total length between four and five inches 20.

19. Tail whitish below; under parts and feet whitish; N. D. southwestward
Sorex merriami Dobson Merriam Shrew
Tail buffy below; under parts and feet pale grayish; generally distributed
Sorex cinereus Kerr Masked Shrew

20. Fourth unicuspid tooth about as large as third; under side almost the same color as back; rostrum (from between eyes to snout) narrow and depressed; New England through W. Va.
Sorex dispar Batchelder Gray Shrew
Fourth unicuspid smaller than third; under side paler than back; rostrum wide and depressed or narrow and elevated 21.

21. Back and sides the same color, under parts slightly lighter; Maine to Wis., southward to Georgia

Sorex fumeus Miller Smoky Shrew

Tricolor, back, sides and under parts of distinctly different shades; Maine to S. D.

Sorex arcticus Kerr Saddle-backed Shrew

22. Third unicuspid tooth in upper jaw not smaller than the fourth 23.

Third unicuspid smaller than the fourth 25.

23. Tail definitely bicolor, brown above, yellowish below; with wide distribution, including the area from Wash. to N. D. and southward to northern N. M.

Sorex cinereus Kerr Masked Shrew

Tail not markedly bicolor; found in Oregon and Cal. 24.

24. Total length about three and one-half inches; eastern Oregon

Sorex preblei Jackson Preble's Shrew

Total length about four inches; Sierra Nevadas in Cal.

Sorex lyelli Merriam Mount Lyell Shrew

25. Lower parts practically as dark as upper; tail sharply bicolor, whitish below; Pacific states northward

Sorex trowbridgii Baird Trowbridge Shrew

Lower parts lighter than upper; tail not sharply bicolor 26.

26. Grayish; body over one and one-half times the tail length; southern Cal.

Sorex ornatus Merriam California Shrew

Brownish; body less than one and one-half times the tail length; Rocky Mountain states and Pacific coast into Cal. 27.

27. About six inches in total length; coastal area of Oregon and northern Cal.

Sorex pacificus Coues Pacific Shrew

About four and one-half inches in total length; Rocky Mountain states 28.

28. Exposed part of upper front, and largest side, teeth about as deep as wide

Sorex obscurus Merriam Dusky Shrew

Exposed part of these teeth considerably wider than deep

Sorex vagrans Baird Wandering Shrew

29. Tail long and almost hairless; with ten upper and eight lower incisor teeth (Marsupials) 30.

Tail hairy; less than ten upper and eight lower incisors (Carnivores) 33.

30. Mouse or rat size, total length seldom as much as fifteen inches (Not native to North America, but frequently accidently brought in with fruit. Not keyed to species.)

Marmosa Gray Mouse Opossums

Larger, total length about thirty inches in adult 31.

31. Tail about one-third of total length; N. Y. to Wis. and Texas; also introduced into Cal.

Didelphis virginiana virginiana Kerr Virginia Opossum

Tail about one-half of total length; Georgia to Texas 32.

32. Color grizzled-gray; tail dark only at base; Ga. to La.

Didelphis virginiana pigra Bangs Florida Opossum

With a grizzled-gray and a dark phase; tail dark about halfway from base; southern Texas
Didelphis mesamericana texensis (Allen) Texas Opossum

33. With four toes on hind foot Cats and Wolves 34.
With five toes on hind foot 51.

34. Cat-like; claws much curved, can be drawn back into sheaths; with thirty or less teeth; Family *Felidae* Cats 35.
Dog-like; claws only slightly curved and not fully retractile; with forty-two teeth; Family *Canidae* Wolves, Coyotes, Foxes 44.

35. Tail short, one-fifth to one-ninth of total length; with three teeth behind the canines on each side of upper jaw 36.
Tail long, one-third to one-fourth of total length; with four teeth behind the canines on each side of upper jaw 40.

36. Ear tips with prominent tufts of hair; tail black all around at tip; northern states
Lynx canadensis Kerr Canada Lynx
Ear tips without prominent tufts; tip of tail black only on the upper side; generally distributed (Four common subspecies given here.) 37.

37. Last third of tail black; Pacific coastal regions
Lynx rufus fasciatus Raf. Pacific Bobcat
Less than last third of tail black 38.

38. With several dark bands on the tail, but not definitely one or two black ones before the black tip; generally distributed
Lynx rufus rufus (Schreber) Common Bobcat
With one or two black bands on the tail (in addition to any reddish bands) before the black tip; western states 39.

39. With two black bars before the black tip of the tail; eastward to Colorado and Wyoming
Lynx rufus pallescens Merriam Mountain Bobcat
(*Lynx uinta* Merriam)
With one black bar and one or more reddish ones before the black tip; southwestern states
Lynx rufus baileyi Merriam Plateau Bobcat

40. Very large, reaching eight feet in total length; color rather uniformly dull yellowish-brown; formerly generally distributed, but now mostly restricted to mountains of the western states
Felis concolor Linn. Cougar, Panther, Puma, Mountain Lion
(Includes *F. oregonensis* Raf., the western form, and *F. couguar* Kerr., the almost extinct eastern form.)
Smaller; if over four feet, then with a spotted or mottled pattern 41.

41. Generally distributed, usually domesticated but sometimes running wild and attaining greater size and longer fur than under domestication
Felis domestica Linn. House Cat
Found wild only in southwestern U. S. along the Mexican border 42.

42. One color, grizzled-gray to rusty-red
Felis cacomitli Berlandier Jaguarundi, Eyra Cat
Yellowish to grayish, with prominent dark markings 43.

43. Yellowish, heavily marked with small black spots, which are often grouped to form rosettes; total length of adult about six feet
Felis hernandesii (Gray) Jaguar, American Leopard
Yellowish to gray, heavily marked with dark blotches, bars or rings; about three feet long
Felis pardalis griffithii (Fischer) Ocelot

44. Total length usually less than three and one-half feet; pupil of eye elliptical; upper incisors without definite sides lobes at the level of the gums Foxes 45.
Total length usually more than three and one-half feet; pupil of eye round; upper incisors with definite side lobes at the level of the gums Wolves and Coyotes 49.

45. Tail without under fur; long hairs of tail coarse; back usually grizzled gray and black; generally distributed
Urocyon cinereoargenteus (Schreber) Gray Fox
Tail with dense, soft under fur; long hairs of tail silky; back usually reddish or brownish-yellow, sometimes black or black, tipped with white 46.

46. Tail white-tipped; total length of adult about three and one-half feet 47.
Tail with a black or very dark brown tip; total length seldom as much as three feet 48.

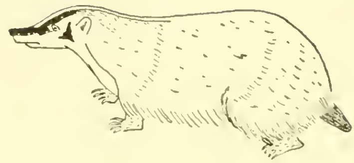
47. Legs largely black; generally distributed
Vulpes fulva (Desmarest) Common Red Fox
(Several subspecies, including *macroura* Baird, *necator* Merriam and *cascadensis* Merriam.)
Feet black; legs dark buff; northern plains
Vulpes regalis Merriam Northern Plains Red Fox
(Now considered to be a subspecies of the preceding.)

48. Ears moderately large; in the western plains
Vulpes velox (Say) Kit Fox, Prairie Fox
Ears about as long as face; along the western Mexican border
Vulpes macrotis Merriam Long-eared Kit Fox

49. Under fur of back reddish-brown; total length less than four feet; weight thirty-five to forty pounds; central and western states
Canis latrans Say Prairie Wolf, Coyote
(Many intergrading subspecies, including *lestes* Merriam, *estor* Merriam and *ochropus* Eschscholtz)
Under fur of back grayish-brown; total length over four feet; weight sixty to one hundred pounds; formerly generally distributed, but now mostly in the western states 50.

50. Sides mostly grayish; often reaching six feet; first upper molar with obscure basal ridge on outer side and with outer posterior cusp scarcely smaller than outer anterior cusp; formerly generally distributed
Canis lupus Linn. Gray or Timber Wolf
(Many intergrading subspecies, including *lycaon* Schreber, *gigas* (Townsend) and *nubilus* Say)
Sides mostly rusty; size smaller, not over five and one-half feet in total length; first molar in upper jaw with pronounced basal ridge on outer

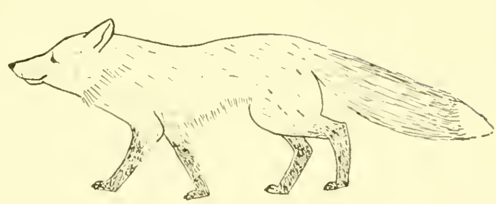
RACCOON



BADGER

BLACK BEAR

COYOTE



RED FOX

side and with outer posterior cusp distinctly smaller than outer anterior cusp; formerly Ill. to Fla. and Texas

Canis niger Bartram Red Wolf

(Includes C. *rufus* (Audubon & Bachman))

51. Very large mammals, weighing up to nine hundred pounds; tail very short; Family *Ursidae* Bears 52.

Much smaller, not over fifty pounds; tail moderate to long 55.

52. Profile of face concave or "dished in"; claws of fore feet twice as long as those on hind feet; with a long-haired hump on the shoulders; Great Plains and Rockies

Ursus horribilis Ord Grizzly Bear

Profile almost straight; claws of fore feet only slightly longer than those on hind feet; no long-haired hump on the shoulders 53.

53. In most of wooded United States except the extreme southeastern and Gulf states

Ursus americanus Pallas Black Bear (Cinnamon or Brown Bear are color phases of this species)

(*Euarctos americanus* (Pallas))

From eastern Texas to Florida and Georgia (Now considered to be subspecies of the preceding) 54.

54. With the region between and back of the eyes high arched; Georgia to Ala.

Ursus floridanus (Merriam) Everglades Black Bear

(*Euarctos floridanus* (Merriam))

With the region between and back of the eyes almost flat; from La. into eastern Texas

Ursus luteolus Griffith Louisiana Black Bear

(*Euarctos luteolus* (Griffith))

55. Tail with a series of six or more definite dark rings; Family *Procyonidae* 56.

Not so; Family *Mustelidae* 58.

56. Tail about one-half of total length; body long and slender; weight of adult about two and one-half pounds; in the southern states from Texas westward

Bassariscus astutus (Lichtenstein) Ring-tailed Cat, Cacomistle

Tail about one-third of total length; body thick set; weight of adult about fifteen pounds or more 57.

57. Dark rings on tail almost as wide as the lighter spaces between; color grizzled gray, brown or black; generally distributed

Procyon lotor (Linn.) Raccoon

Dark rings on tail considerably narrower than the lighter areas between; pale gray and black; desert regions of California

Procyon pallidus Merriam Desert Raccoon

(Now considered to be a subspecies of the preceding.)

58. Claws of fore feet over one inch long; head and body very flat and broad; hair long, silvery, gray grizzled with black; head with a narrow, median, white stripe and a white patch below each eye; generally distributed

Taxidea taxus (Schreber) American Badger
Not as above 59.

59. Body color pattern definitely of black and clear white; claws not retractile; feet not webbed Skunks 60.
Color brown; any whitish markings with an evident brownish or yellow tinge, or else all white, except the tip of the tail; either with the claws partly retractile or with the toes webbed 69.

60. Usually with one or two white stripes on the body, or sometimes mostly black 61
With more than two white stripes on the body, these stripes usually interrupted to form a series of blotches or spots 63.

61. White spot of head forking to form a pair of white bands, one on each side of the body; generally distributed
Mephitis mephitis (Schreber) Striped Skunk
(Many intergrading subspecies, including *nigra* (P. & B.), *mesomelas* Lichtenstein and *estor* Merriam)
With a broad, uninterrupted dorsal stripe from head to tail; along the Mexican border 62.

62. Under side of tail with only a few black hairs; Texas to Ariz.
Conepatus mesoleucus (Lichtenstein) Hog-nosed Skunk
Under side of tail with much black; coastal region of Texas
Conepatus leuconotus texensis Merriam Texas Hog-nosed Skunk

63. West of the Rockies
Spilogale gracilis Merriam Western Spotted Skunk
(Many intergrading subspecies, including *saxatilis* (Merriam) and *phenax* Merriam)
East of the Rocky Mountain crest 64.

64. In the southeastern states to Alabama 65.
Eastward to Mississippi (mostly west of the Mississippi River) 66.

65. With a white patch on the under side of the tail, near the base, as well as a white tip; Florida
Spilogale ambarvalis Bangs Florida Spotted Skunk
Tail black, except for the white tip; Maryland to Ala.
Spilogale putorius (Linn.) Allegheny Spotted Skunk

66. Very little or no white on the tail; prairie states
Spilogale interrupta (Raf.) Prairie Spotted Skunk
Last quarter of the tail white 67.

67. White stripes as narrow as, or narrower than, the black areas between them; Miss. to Texas
Spilogale indianola Merriam Gulf Spotted Skunk
Lateral stripes usually wider than the black areas above them; distribution more westerly or northerly 68.

68. White spot on forehead large; N. M. into Texas
Spilogale leucoparia Merriam Rio Grande Spotted Skunk
White spot on forehead narrow; N. M. into Colo.
Spilogale tenuis Howell Rocky Mountain Spotted Skunk

69. Feet fully webbed; total length of adult forty to forty-five inches; tail long and tapering, and sparsely haired; generally distributed

Lutra canadensis (Schreber) Otter

Feet scarcely or not webbed; less than forty inches long; tail well haired 70.

70. Form bear-like; color above dark brown to black, with a band of yellow along each side Wolverines 71.

Form squirrel-like; color not so 72.

71. Head grizzled gray and brown; along the Canadian border and down the Rockies to Colo.

Gulo luscus (Linn.) Canadian Wolverine

Head pale gray above; from the Sierra Nevada Mountains of California northward

Gulo luteus Elliot Southern Wolverine

(Now considered to be a subspecies of the preceding.)

72. Total length about two feet or over; legs as dark as, or darker than, the body color 73.

Total length less than twenty inches; legs seldom darker than the back—*Mustela* Linn. (*Putorius* Cuvier) Weasels (A difficult group to identify by external characters, especially in winter, when many of them turn white.) 77.

73. With five teeth on each side of the upper jaw behind the canines—*Martes* Pinel (*Mustela* Linn.) 74.

With four teeth on each side of the upper jaw behind the canines—*Mustela* Linn. (*Putorius* Cuvier) 76.

74. With a dark throat patch; head and shoulders grayish; northern and Pacific states

Martes pennanti (Erxleben) Fisher, Pekan

With a light buff or yellowish patch on the throat; ears often with white or buffy edges 75.

75. Along the Canadian boundary westward about to Minn., thence northwestward

Martes americana (Turton) Eastern Marten

In Washington and Oregon; light areas on throat and chest larger than in the preceding species, often extending on to the front legs

Martes caurina (Merriam) Western Marten

76. Color yellowish-brown, with blackish feet and a black, mask-like band across the eyes; plains states

Mustela nigriceps (Audubon & Bachman) Black-footed Ferret

Rather uniformly dark brown, except for a white spot on the chin and occasional irregular white spots on the body; generally distributed

Mustela vison Schreber Mink

(Many intergrading subspecies)

77. Seldom over eleven inches in total length; tail (not including hair) about one-fifth or less total length; no black at the tip of the tail or with only a few black hairs (Two common subspecies are given here) 78.

Often larger; tail more than one-fifth total length; with black at the tip of the tail, often for the last quarter 79.

78. In the northwestern states to Minn.; often turning white in winter
Mustela rixosa rixosa (Bangs) Canadian Least Weasel
In the northeastern states to Minn., and southward in the mountains; less often turning white in winter
Mustela rixosa allegheniensis (Rhoads) Allegheny Least Weasel

79. Total length not over thirteen inches; tail (not including hair) less than one-third total length; usually becoming white in winter; northern states, extending southward along the mountains (Two common subspecies are given here) 80.
Total length often exceeding thirteen inches in many subspecies; tail about or over one-third total length; becoming white in winter in most, but not all, subspecies; generally distributed (Several common subspecies are given here) 81.

80. Usually white in winter; in summer pelage, the color of the upper parts does not extend on to the belly; northern states
Mustela erminea cicognanii Bonaparte Bonaparte's Short-tailed Weasel or Ermine
May or may not be white in winter, depending upon locality; in summer pelage, the color of the upper parts often extends well on to the belly; Puget Sound region
Mustela erminea streatori (Merriam) Puget Sound Short-tailed Weasel or Ermine

81. With a very short black tip to the tail; turning white in winter; northern New England
Mustela frenata occisor (Bangs) New England Long-tailed Weasel or Ermine
Tail usually black for the last quarter or more 82.

82. Tail usually black for more than the last quarter; turning white in winter in the northern part of its range; east of the Mississippi
Mustela frenata noveboracensis (Emmons) New York Weasel
Tail black for about the last quarter; west of the Mississippi 83.

83. With a conspicuous white band crossing the face between the eyes and the ears; not usually turning white in winter; along the Mexican border
Mustela frenata frenata Lichtenstein Bridled Weasel
No such facial marking; may or may not turn white in winter; usually more northerly in distribution 84.

84. In the plains states 85.
In the mountain and Pacific states 86.

85. Usually turning white in winter; in summer pelage, upper lip white and under parts buff; northern plains
Mustela frenata longicauda Bonaparte Plains Long-tailed Weasel
Usually turning white in winter; in summer pelage, upper lip not white and under parts yellow; Ozark region
Mustela frenata primulina Jackson Missouri Weasel

86. With a white spot between the eyes; usually not turning white in winter; southern Pacific states

Mustela frenata xanthogenys Gray California Long-tailed Weasel

Not so; usually turning white in winter 87.

87. In summer pelage, color of upper parts extending well on to sides of belly; northern Pacific states

Mustela frenata washingtoni (Merriam) Washington Long-tailed Weasel

In summer pelage, color of upper parts ending sharply on the sides; Pacific and mountain states

Mustela frenata nevadensis Hall Mountain Long-tailed Weasel (Includes *M. arizonensis* (Mearns (part))

KEY TO THE PRINCIPAL GENERA AND SPECIES OF GNAWING MAMMALS

1. With two very small incisor teeth behind the pair of large upper incisors; rabbits or rabbit-like animals 2.

With only two upper incisor teeth; not rabbit-like 16.

2. No visible tail; hind legs not much longer than fore legs; Family *Ochotonidae* Pikas 3.

With a short tail; hind legs considerably longer than fore legs; Family *Leporidae* Hares and Rabbits 4.

3. Under parts without buffy tinge; with an indistinct grayish "collar" on the shoulders; Rocky and Cascade Mts. southward through Oregon

Ochotona princeps (Richardson) Rocky Mountain Pika or Cony

Under parts with buffy tinge; no grayish collar; in the Sierra Nevadas and mountains between them and the Rockies

Ochotona schisticeps (Merriam) California Pika or Cony (Considered to be a subspecies of the preceding)

4. Hind foot over four and three-quarters inches long in the adult; ears often black tipped or black bordered; fur becoming white in winter, in some but not all species, excepting the ears, which are then gray tipped 5.

Hind foot less than four and one-half inches long; ears usually not so definitely black tipped, but often with a blackish tinge toward the tips; not becoming white in winter Cottontails 9.

5. Ears and hind legs considerably longer, proportionally, than those of the domestic rabbit; ears over three and one-half inches long in the adult Jack Rabbits 6.

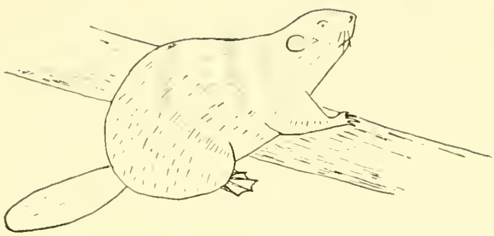
Ears not proportionally longer than those of the domestic rabbit; ears less than three and one-half inches long Snowshoe Rabbits 8.

6. No black on tail; fur becoming white in winter in colder parts of its range; from Iowa westward

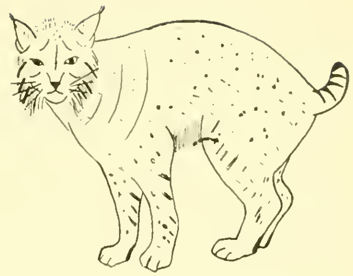
Lepus townsendii Bachman White-tailed Jack Rabbit

(*Lepus campestris* (Bachman))

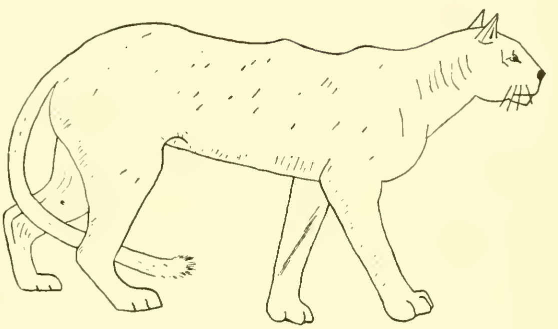
Upper part of tail partly or mostly black; fur not becoming white in winter 7.



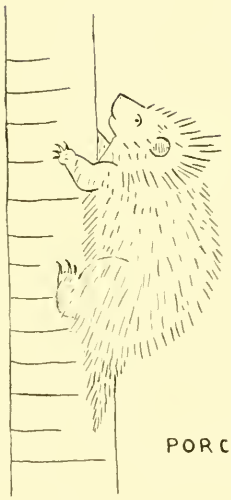
BEAVER



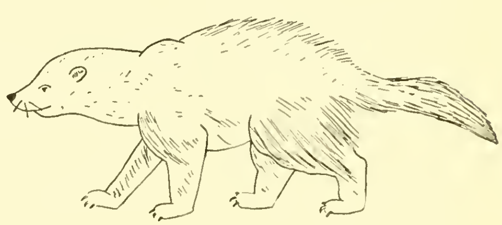
BOBCAT



COUGAR OR MOUNTAIN LION



PORCUPINE



WOLVERINE

7. Ears with definite black tips; upper part of tail mostly black; from Kansas and Nebraska to the Pacific coast

Lepus californicus Gray Black-tailed Jack Rabbit (Many subspecies)

Tips of ears only slightly blackish posteriorly; upper part of tail black only on basal half; Ariz. and N. M. southward

Lepus alleni Mearns White-faced or Antelope Jack Rabbit

8. Soles of feet usually light colored; fur turning white in winter; northern states, and southward in the mountains

Lepus americanus Erxleben Varying Hare, Snowshoe Rabbit (Many intergrading subspecies)

Soles of feet usually dark tinted; fur not turning white in winter; western Wash. and Oregon

Lepus washingtonii Baird Coastal Snowshoe Rabbit (Now considered to be a subspecies of the preceding)

9. Tail uniformly colored; small mammals, not over twelve inches in the adult; western states

Sylvilagus idahoensis (Merriam) Pigmy Rabbit (*Brachylagus idahoensis* (Merriam))

Tail pale below; becoming larger 10.

10. Tail gray below; swamp or marsh habitat; southeastern states along the coast from Va. to Fla. and La.

Sylvilagus palustris (Bachman) Marsh Rabbit

Tail white below 11.

11. Tops of hind feet brown; hind feet getting to be slightly over four inches long; Ill. to Ga. and Texas

Sylvilagus aquaticus (Bachman) Swamp Rabbit

Tops of hind feet white or pale buffy; hind feet usually much shorter 12.

12. Tail about as wide as long, thickly haired; under parts grayish; Pacific coastal region

Sylvilagus bachmani (Waterhouse) Brush Rabbit

Tail somewhat longer, thinly haired 13.

13. Tops of hind feet usually white; from S. D. and Okla. westward 14.

Tops of hind feet usually buffy; eastward from Wyo. and Colo. 15.

14. Ear, from crotch, less than two and three-eighths inches long, thickly haired within; general color brownish

Sylvilagus nuttallii (Bachman) Rocky Mountain Cottontail

Ear slightly longer, extending beyond nose, when laid forward; ears black-tipped and thinly haired within; general color grayish

Sylvilagus audubonii (Baird) Western Cottontail

15. Under parts pinkish-buff, well streaked with black; with a lengthwise black band between the ears; New England to Ala.

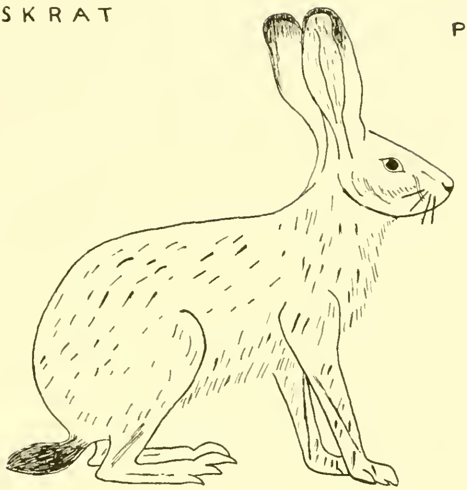
Sylvilagus transitionalis (Bangs) New England Cottontail

Under parts sprinkled, not streaked, with black; N. Y. to the Rockies

Sylvilagus floridanus (Allen) Common Cottontail (Many subspecies)

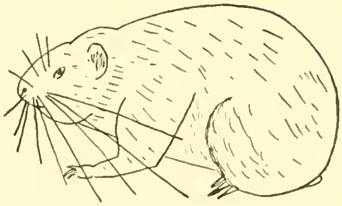
MUSKRAT

PRAIRIE DOG



BLACK-TAILED JACK RABBIT

PIKA OR CONY



MOUNTAIN BEAVER

16. Tail very flat, broad and hairless; toes of hind feet with evident webs; claw of second toe double; adults somewhat over three feet in total length (the largest native rodent); generally distributed over the United States, but almost exterminated in many localities; Family *Castoridae*
  Castor canadensis Kuhl Beaver
 Not so 17.

17. Body and short tail bristling with large, stiff quills; adults about two to three feet in total length; Family *Erethizontidae* Porcupines 18.
 Not so 19.

18. Hairs whitish at tips; New England to Penna. and westward through the Great Lakes Region
  Erethizon dorsatum (Linn.) Canada Porcupine
 Hairs with greenish-yellow tips; westward and southward from N. D.
  Erethizon epixanthum Brandt Yellow-haired Porcupine
  (Now considered to be a subspecies of the preceding)

19. Tail so short that the mammal appears superficially to be without a tail; Pacific states; Family *Aplodontiidae*
  Aplodontia rufa (Raf.) Mountain Beaver, Sewellel
 With an evident tail 20.

20. With four or more cheek teeth (premolars and molars) on each side of each jaw 21.
 With three grinding teeth on each side of each jaw 112.

21. Tail thinly haired or almost bare 22.
 Tail bushy or at least well covered with hair; Family *Sciuridae* 23.

22. With fur-lined cheek pouches opening on each side of the mouth but not connecting with the mouth 63.
 No such pouches 112.

23. Body very heavy set; tail short, less than one-fourth of total length, in most cases Marmots and Prairie Dogs 24.
 Body more slender; tail usually, but not in all cases, longer Chipmunks, Squirrels, Ground Squirrels, etc. 29.

24. Thumb small, with flat nail; tail without a conspicuous black or white tip 25.
 Thumb with a claw, the same as the fingers; tail with a black or white tip 27.

25. Upper parts largely grizzled black and white; northwestern U. S. to Montana
  Marmota caligata (Eschscholtz) Hoary Marmot, Whistler
 Upper parts reddish-brown 26.

26. Under parts buff to brown; northern states
  Marmota monax (Linn.) Woodchuck, Groundhog, Marmot
 Under parts yellowish to light brown; with a light band crosswise before the eyes; in the Rockies and westward
  Marmota flaviventris (Audubon & Bachman)
  Yellow-bellied Marmot

27. Tail with a black tip; in the Great Plains
Cynomys ludovicianus (Ord) Black-tailed Prairie Dog
Tail with a white tip 28.

28. Distal half of tail gray, edged with white; southern Rockies into Colo.
Cynomys gunnisoni (Baird) Gunnison Prairie Dog
Distal half of tail white; northern Rockies into Colo.
Cynomys leucurus Merriam White-tailed Prairie Dog

29. With definite stripes on back and sides 30.
No definite color stripes, except sometimes a mid-dorsal stripe or band 43.

30. With lengthwise stripes on the sides of the head 31.
No definite stripes on the sides of the head 38.

31. Mid-dorsal stripe bordered on each side by a much wider band; with four upper grinding teeth on each side; eastern and central states
Tamias striatus (Linn.) Eastern Chipmunk
Mid-dorsal dark stripe bordered on each side by a lighter stripe of about equal width; with five upper grinding teeth on each side; west of the Mississippi, except in the northern states, where it spreads into Wis. and Michigan Western Chipmunks 32.

32. Light spot behind ear indistinct or grayish 33.
With a white spot behind each ear 34.

33. Stripe through eye and edges of ears black; northern Rocky Mountain area and Pacific states
Eutamias amoenus (Allen) Klamath Pine Chipmunk
Stripe through eye and ears brown; in the Cal. coastal ranges
Eutamias merriami (Allen) Merriam's Chipmunk

34. Stripe through eye brown; edges of ears grayish; small, about seven inches in total length; generally distributed over the western and northern states to Michigan
Eutamias minimus (Bachman) Little or Sagebrush Chipmunk
Stripe through eye black or blackish; larger 35.

35. Large, about ten inches in total length; edges of tail whitish; hairs on backs of ears banded with two or three colors; Pacific states 36.
Smaller, about eight to nine inches; edges of tail buffy 37.

36. With a black stripe below the ear; white spot behind ear as long as ear; Cal. and Nevada
Eutamias quadrimaculatus (Gray) Long-eared Chipmunk
With a reddish-brown stripe below the ear; white spot behind ear smaller than ear; Pacific states
Eutamias townsendii (Bachman) Townsend's Chipmunk

37. Crown and shoulders gray; not much black in stripes; Rocky Mountain states west to the Sierras
Eutamias quadrivittatus (Say) Say's Chipmunk
Crown and shoulders brown; with definitely black stripes on body; Cal. into Nevada
Eutamias speciosus (Merriam) Lodgepole Pine Chipmunk

38. Upper parts with many dark and light stripes, each dark stripe with a central row of light spots; central states

Citellus tridecemlineatus (Mitchill) Thirteen-striped Ground Squirrel

With one light stripe on each side, with or without darker stripes above or below it 39.

39. Upper incisors slender and almost straight; crown, sides of neck and shoulders chestnut, contrasting with the rest of the dark upper parts Subgenus *Callospermophilus* Merriam 40.

Upper incisors heavy and recurved; no light mantle Subgenus *Ammospermophilus* Merriam 41.

40. With a well developed dark stripe above the white stripe; Oregon and Cal.

Citellus chrysodeirus (Merriam) Golden Mantled Ground Squirrel

(Now considered to be a subspecies of the following)

Dark stripe above the light stripe poorly developed or absent; Rocky Mountain and Pacific states

Citellus lateralis (Say) Say's Mantled Ground Squirrel

41. Tail grayish or mixed black and white below; southwestern states

Citellus harrisii (Audubon & Bachman) Gray-tailed Antelope Ground Squirrel

Tail white below 42.

42. Hairs of tail with one black band; southwestern states to Idaho and Oregon

Citellus leucurus (Merriam) White-tailed Antelope Ground Squirrel

Hairs of tail with two black bands; in southern California

Citellus nelsoni (Merriam) Nelson's Antelope Ground Squirrel

43. Front and hind legs on each side joined together by a wide fold of skin extending from the side of the body Flying Squirrels 44.

Not so 45.

44. Under parts white to roots of hairs; total length usually less than ten inches; eastern and central states

Glaucomys volans (Linn.) Eastern Flying Squirrel

Under parts with hairs dark at base; usually larger; northern and western states

Glaucomys sabrinus (Shaw) Northern or Western Flying Squirrel

(Many subspecies)

45. Length of tail (not including hair) about one-third of total length; tail not bushy 46.

Tail almost or about one-half total length; tail bushy 53.

46. Back with light spots or blotches 47.

Not so 48.

47. Tail included about three times in total length; Mexican border northward to Neb.

Citellus spilosoma (Bennett) Spotted Sand Squirrel

Tail included about four times in total length; northwestern U. S.

Citellus washingtoni Howell Washington Ground Squirrel

48. Tail included about three times in total length 49.

Tail included about four times in total length 51.

49. Back uniformly colored, except for the white tips to the hairs; adults about ten inches in total length; hair coarse and stiff; Ariz. to Cal.

Citellus tereticaudus (Baird) Round-tailed Ground Squirrel

Back grizzled or dark spotted; adults about fourteen to fifteen inches in total length 50.

50. Limbs rusty-yellow; tail included slightly more than three times in total length; northwestern U. S.

Citellus columbianus (Ord) Columbian Ground Squirrel

Limbs grayish; tail included slightly less than three times in total length; northern plains area; introduced into N. J.

Citellus franklinii (Sabine) Franklin's Ground Squirrel

51. Upper parts grayish; hair very soft; Wash. to Nev. and Utah

Citellus townsendii (Bachman) Townsend's Ground Squirrel (Includes C. *mollis* (Kennicott))

Upper parts brownish 52.

52. Tail yellowish beneath; Mont. to Wyo. and Nevada

Citellus richardsonii (Sabine) Richardson's Ground Squirrel, Flickertail

Tail reddish beneath; Great Basin, Oregon and Idaho to Nev. and Cal.

Citellus beldingi (Merriam) Belding's Ground Squirrel

53. Hairs on sides of tail not much longer than those above or below; back often blotched or dappled; not living in trees; southwestern U. S. and Pacific states (Subgenus *Otospermophilus*) Rock Squirrels 54.

Hairs much longer on sides of tail than above or below; back evenly colored; arboreal; generally distributed 55.

54. With a central dark patch on the neck and shoulders; Pacific states

Citellus beecheyi (Richardson) California Rock Squirrel

Not so; Colo. to Texas and Cal.

Citellus variegatus grammurus (Say) Arizona Rock Squirrel

55. With four grinding teeth in each side of upper jaw; color variable, but usually rusty to blackish; hairs of tail tipped with yellow, not white; total length of adult twenty to twenty-seven inches Fox Squirrels 56.

With five grinders in each side of upper jaw, the first quite small or sometimes absent; reddish or gray; large or small 57.

56. With several color phases, even in the same subspecies, from pale gray, through rusty-red (the most common phase) to black; eastern and central states

Sciurus niger Linn. Fox Squirrel

Color mixed black and white, often appearing gray; with yellowish-brown dorsal stripe evident in winter but indistinct in summer pelage; Ariz. and N. M.

Sciurus arizonensis Coues Arizona Gray Squirrel

57. With conspicuous tufts of long hairs on the ears; Colo. southwards 58.
No conspicuous ear tufts 59.

58. White beneath; Colo. southwards
Sciurus aberti Woodhouse Tuft-eared Squirrel
Black beneath; Arizona
Sciurus kaibabensis Merriam Kaibab Squirrel

59. Small; adults seldom reaching fourteen inches in total length; rusty-red above and white to rusty below; first upper premolar vestigial to absent 60.
Larger; adults reaching seventeen to twenty inches in total length; first upper premolar usually present; chiefly grayish above 62.

60. Under parts rusty-red; west of the Rockies
Tamiasciurus douglasii (Bachman) Western Chickaree
Under parts whitish or dusky 61.

61. Hairs of tail tipped with white; in southern Rocky Mountain states
Tamiasciurus fremonti (Audubon & Bachman)
Fremont Chickaree
Hairs of tail with yellowish tips; in northern Rocky Mountain states and most of the forested area east of the Rockies
Tamiasciurus hudsonicus (Erxleben) Red Squirrel, Chickaree

62. Color of back a brownish-gray mixture, with gray predominating; in forested areas of the eastern and central states; introduced in some western states
Sciurus carolinensis Gmelin Eastern Gray Squirrel
Color of back silvery-gray; tail very broad, with the hairs often three inches long; Pacific states
Sciurus griseus Ord Western Gray Squirrel

63. Thick-bodied mammals with very short legs; fore feet much enlarged for digging; eyes and ears very small; Family *Geomyidae* Pocket Gophers 64.
Small, slender mammals, usually adapted for leaping; eyes and ears usually large; tail about as long as the body, often with a terminal tuft of hair; Family *Heteromyidae* Pocket Mice and Pocket Rats 80.

64. Outer surface of upper incisors not grooved or with a shallow groove near the inner edge; lower molars with anterior as well as posterior plates of enamel; Rocky Mountain and Pacific states Western Pocket Gophers 65.
Outer surface of upper incisors each with an almost central groove or with two grooves, the deeper one near the outer edge; lower molars with enamel plates posteriorly only 76.

65. Upper incisors protruding beyond tip of nasal bones 66.
Not so 69.

66. Ears small but pointed; Idaho and Nevada
Thomomys townsendii (Bachman) Townsend's Pocket Gopher
Ears merely a thickened rim 67.

67. Incisors projecting slightly; Cal., Ariz. and Utah
Thomomys bottae (E. & G.) California Pocket Gopher
Incisors projecting markedly 68.

68. In Oregon
Thomomys bulbivorus (Richardson) Camas Pocket Gopher
From Texas to Ariz.
Thomomys baileyi Merriam Sierra Blanca Pocket Gopher

69. Ears small 70.
Ears relatively large 72.

70. Ears pointed; northwestern states
Thomomys fuscus Merriam Brown Pocket Gopher
Ears rounded; southwestern states 71.

71. Upper incisors definitely grooved; coat yellowish-brown
Thomomys fulvus (Woodhouse) Tawny Pocket Gopher
Upper incisors with no, or very faint, grooves; coat yellowish-gray
Thomomys perpallidus (Merriam) Desert Pocket Gopher

72. With five or six pairs of mammae 73.
With four pairs of mammae 74.

73. With six pairs of mammae; color gray; upper incisors distinctly grooved; Colo. northward
Thomomys talpoides (Richardson) Plains Pocket Gopher
With five pairs of mammae; color brown; upper incisors very faintly grooved; Colo. and Utah
Thomomys fossor Allen Mountain Valley Pocket Gopher

74. Incisor grooves scarcely visible; with considerable white on under side and on throat; Sierra Mts.
Thomomys alpinus Merriam Alpine Pocket Gopher
Upper incisors with distinct grooves 75.

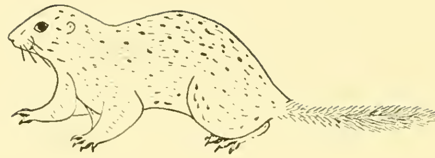
75. Under parts usually buff; central Oregon into Cal. and Nevada
Thomomys monticola Allen Mountain Pocket Gopher
Under parts usually with some irregular white patches; Wash. and northern Oregon
Thomomys douglasii Richardson Columbia Pocket Gopher

76. Upper incisors each with one groove; no posterior enamel plates on upper middle two cheek teeth; Colo. southwards
Cratogeomys castanops (Baird) Chestnut-faced Pocket Gopher
Upper incisors each with two grooves; with enamel on front and back of upper cheek teeth; widely distributed over the central and southern states 77.

77. Rarely over nine inches in total length; color dark brown; Kansas to the Gulf states
Geomys breviceps Baird Southern Prairie Pocket Gopher (and related forms)
Adult length ten to twelve inches; color usually chestnut or reddish brown, a few forms dark to slaty 78.

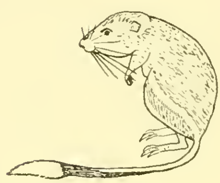
78. With an easily felt longitudinal ridge (sagittal crest) along top of braincase, especially well developed in males; top profile concave; western Wis. and Ind. to the Rockies
Geomys bursarius (Shaw) Northern Prairie Pocket Gopher (and related forms)

EASTERN CHIPMUNK

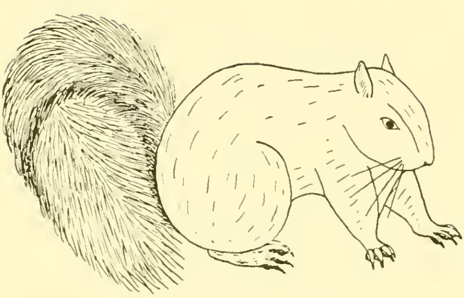


FRANKLIN'S GROUND SQUIRREL

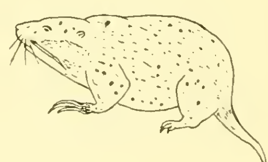
HOUSE RAT



KANGAROO RAT



GRAY SQUIRREL



POCKET GOPHER

Usually with two ridges not close enough together to form a sagittal crest; top profile convex; southeastern states 79.

79. Color sooty or tawny above; with some white on throat and under parts; Fla.

Geomys floridanus (Audubon & Bachman) Florida Pocket Gopher

Color reddish-brown above, buff below; Ga. and Ala.

Geomys tuza (Ord) Southern Pocket Gopher

80. Normal hairs mixed with stiff spines, which are flattened and grooved on the anterior side; southern Texas

Liomys irroratus texensis (Merriam) Texas Spiny Pocket Mouse

Not so 81.

81. Total length of adults nine to twelve inches; tail with a dark stripe below; usually with a conspicuous light stripe across the thigh; southwestern states (A very difficult group, in need of more taxonomic study, separated mainly on range. A few common species are given here.) 82.

Smaller; tail with no dark stripe below 94.

82. Usually with a small fifth toe or claw high on the inside of the foot 83.

Usually with only four toes 90.

83. From Oregon southward along the Cal., Nevada and Ariz. border into Texas and Mexico 84.

Primarily in Cal. 85.

84. Lower incisors flat, chisel-shaped; Nevada region

Dipodomys microps (Merriam) Chisel-toothed Kangaroo Rat

Lower incisors rounded; Oregon to Texas

Dipodomys ordii Woodhouse Ord's Kangaroo Rat

85. In the southern part of Cal., from San Bernardino and Kern Counties southward, on the desert slopes of the mountains

Dipodomys agilis Gambel Nimble Kangaroo Rat

North of San Bernardino, or in the Mohave or Panamint areas 86.

86. Large, about fourteen inches in total length; tail not much longer than rest of animal; southwest border of San Joaquin Valley, Cal.

Dipodomys ingens (Merriam) Giant Kangaroo Rat

Smaller, ten to twelve inches in total length; tail usually almost twice as long as the body 87.

87. From southern Oregon to Santa Barbara county, Cal., between the Sierra Nevada and the coastal Redwood belt

Dipodomys heermanni Le Conte Heermann Kangaroo Rat

South and west of the above range 88.

88. In the Mohave Desert and lower Owens Valley, Cal.

Dipodomys mohavensis Grinnell Mohave Kangaroo Rat

Not so 89.

89. At the head of Owens Valley and in the northern Panamint Mts.

Dipodomys panamintinus (Merriam) Panamint Kangaroo Rat

In San Jacinto Valley of east Riverside county
Dipodomys stephensi (Merriam) San Jacinto Kangaroo Rat

90. In western and central Cal. and northward into Oregon; northern subspecies with a white tail tuft
Dipodomys heermanni Le Conte Heermann Kangaroo Rat
In southeastern Cal. or eastward 91.

91. Light buff, with no dark facial markings; total length about fourteen inches; adjoining areas of Cal. and Nevada
Dipodomys deserti Stephens Desert Kangaroo Rat
Darker, with dark facial markings and some black hairs on body 92.

92. About twelve to fourteen inches long; tail usually white-tipped; Ariz. to Texas
Dipodomys spectabilis Merriam Banner-tailed Kangaroo Rat
About nine to ten inches long; tail usually dark tipped 93.

93. In the San Joaquin Valley, Cal.; dark tail stripes (dorsal and ventral) narrower than the light lateral tail stripes
Dipodomys nitratoides (Merriam) Short-nosed Kangaroo Rat
In the Mohave Desert and westward into Texas; dark tail stripes wider than the light ones
Dipodomys merriami Mearns Merriam Kangaroo Rat

94. Base of tail slimmer than central part; soles of hind feet thickly haired; body heavy; head large; found in the arid section where Oregon, Nevada and Cal. meet Kangaroo Mice 95.
Base of tail stouter than central section; soles of hind feet bare to half haired; body slender and mouse-like Pocket Mice 96.

95. Upper parts dark; end of tail dark; fur behind ears brownish
Microdipodops megacephalus Merriam Brown Kangaroo Mouse
Upper parts light; tail more uniformly colored; fur behind ears white
Microdipodops pallidus Merriam Pale Kangaroo Mouse

96. Fur coarse, with stiff or spiny bristles; soles of hind feet usually bare (Subgenus *Chaetodipus*) 97.
Fur soft, without bristles; soles of hind feet usually hairy behind (Subgenus *Perognathus*) 103.

97. Tuft on end of tail less than three-eighths of an inch long 98.
Tuft on end of tail usually over one-half an inch long 99.

98. Tail longer than head and body; Ariz. to Cal.
Perognathus baileyi Merriam Bailey Pocket Mouse
Tail about one-half total length; plains states to the Rockies
Perognathus hispidus Baird Stiff-haired Pocket Mouse

99. Bristles coarse but not spiny; Cal. to Texas
Perognathus penicillatus Woodhouse Desert Pocket Mouse
Bristles spiny 100.

100. Ears elongate; Cal.
Perognathus californicus Merriam California Pocket Mouse
Ears round 101.

101. Stripe along side obscure or absent; southern Cal.

Perognathus spinatus Merriam Spiny Pocket Mouse
With a light stripe along each side 102.

102. Front edge of ear only one-fourth as long as the hind foot; Cal.
Perognathus fallax Merriam Short-eared Pocket Mouse
Front edge of ear about one-third as long as the hind foot; N. M. and Ariz.
Perognathus intermedius Merriam Intermediate Pocket Mouse

103. In the northern plains to Colo. 104.
In the Rocky Mountain and Pacific states 106.

104. Under parts buffy
Perognathus fasciatus Wied Maximillian Pocket Mouse
Under parts white 105.

105. Fur soft; Wyo. southwards
Perognathus flavus Baird Baird Pocket Mouse
Fur coarse; northern plains
Perognathus flavescens (Merriam) Plains Pocket Mouse

106. Small; total length of adult less than six inches 107.
Larger; over six inches in adult specimens 110.

107. Tail about two and one-half to three inches long, about as long as head and body; often with a light lateral stripe 108.
Tail about two inches long, shorter than head and body; light lateral stripe obscure or absent 109.

108. Ears large; Utah to Cal.
Perognathus longimembris (Coues) Fort Tejon Pocket Mouse
Ears small; Colo. to Ariz.
Perognathus apache Merriam Apache Pocket Mouse

109. Tail with very little hair; Texas and N. M.
Perognathus merriami Allen Merriam Pocket Mouse
Tail with moderate amount of hair; Wyo. southward
Perognathus flavus Baird Baird Pocket Mouse

110. Tuft at end of tail over one-half inch long; Utah to Cal.
Perognathus formosus Merriam Long-tailed Pocket Mouse
Tuft at end of tail less than three-eighths of an inch long 111.

111. In central and southern Cal.
Perognathus inornatus Merriam San Joaquin Pocket Mouse
From northern Cal. to Wash. and Idaho
Perognathus parvus (Peale) Oregon Pocket Mouse

112. Tail about one and one-half times as long as head and body; hind legs very long; fore legs short; Family *Zapodidae* Jumping Mice 113.
Tail not much longer than head and body, usually shorter; hind legs not greatly lengthened 118.

113. With a white tip to the tail; only three grinding teeth in each side of the upper jaw; eastern and central states
Napaeozapus insignis (Miller) Woodland Jumping Mouse
No white tip to tail; usually four grinders in each side of upper jaw, the first very small 114.

114. East of the Rockies

Zapus hudsonius (Zimmermann) Hudson Bay Jumping Mouse

In the Rocky Mountain region and westward 115.

115. Under parts much the same color as the upper parts; coastal regions of Cal.

Zapus orarius Preble Coastal Jumping Mouse

Under parts white or only slightly tinged with the color of the upper parts 116.

116. Tail indistinctly bicolor; Rocky mountain region

Zapus princeps Allen Rocky Mountain Jumping Mouse

Tail sharply bicolor—gray above, white below 117.

117. With a distinct, dark dorsal band; Pacific states

Zapus trinotatus Rhoads Oregon Jumping Mouse

(Often considered to be a subspecies of the preceding.)

No distinct, dark dorsal band; Oregon and Cal.

Zapus pacificus Merriam Pacific Jumping Mouse

118. Grinding teeth of the upper jaw with rounded points in two or three lengthwise rows on the crowns 119.

Grinding teeth with flattened crowns showing loops or irregular, triangular folds of enamel; Family *Cricetidae* (part) Native Rats and Mice 144.

119. With the rounded points on the grinding teeth extending in three lengthwise rows; tail practically hairless; introduced species; Family *Muridae* Old World Rats and Mice 120.

With the rounded points on the grinding teeth extending in two lengthwise rows; tail usually hairy; native species; Family *Cricetidae* (part) Native Rats and Mice 123.

120. Total length of adult six to seven inches

Mus musculus Linn. House Mouse

Total length fifteen to seventeen inches 121.

121. Length from nose to root of tail greater than, or occasionally equal to, length of tail; grayish or brownish above, gradually shading to lighter below

Rattus norvegicus (Erxleben) Norway Rat, Common or House Rat

(*Mus norvegicus* or *Epimys norvegicus* of some writers)

Length from nose to root of tail less than length of tail; blackish above or else yellowish-white below 122.

122. Slate colored to black above; slaty-gray to black below

Rattus rattus rattus (Linn.) Black Rat

Reddish-brown above; yellowish-white below

Rattus rattus alexandrinus (Geoffrey) Roof Rat

123. Upper incisors with deep lengthwise grooves 124.

Upper incisors not grooved on front 128.

124. Grayish below; Virginia to Florida and Louisiana

Reithrodontomys humulis (Audubon and Bachman) Harvest Mouse

White to buff below; west of the Mississippi River 125.

125. Large; tail three and one-half or more inches long; western Louisiana to eastern Texas, and northward to Missouri
Reithrodontomys fulvescens (Allen) Golden Harvest Mouse
Smaller; tail less than three and one-half inches long 126.

126. Tail not distinctly bicolor, grayish below; body usually reddish below; in salt marshes along the coast of California
Reithrodontomys raviventris Dixon Red-bellied Harvest Mouse
Tail distinctly bicolor, whitish below; western states 127.

127. Ears often with one or two dark patches each; rostrum (before eye sockets) less than one-third length of skull; S. D. southwards, preferring arid areas
Reithrodontomys montanus (Baird) Desert Harvest Mouse
(Includes *R. albescens* Cary)
Ears usually plain colored; rostrum slightly longer than one-third length of skull; southward and westward from N. D., preferring less sandy areas
Reithrodontomys megalotis (Baird) Upland Harvest Mouse

128. Sole of hind foot naked or almost so 129.
Sole of hind foot hairy; under parts white 130.

129. Under parts gray or buffy; total length about four inches; southern Texas
Baiomys taylori (Thomas) Taylor Baiomys
Under parts white; total length nine or ten inches; N. J. to the Gulf states
Oryzomys palustris (Harlan) Rice Rat

130. Tail shorter than 2.4 in total length; sole of hind foot with four tubercles; western Minn. to central Oklahoma, and westward 131.
Tail longer than 2.4 in total length; sole of hind foot with five or six tubercles; generally distributed; *Peromyscus* Gloger White-footed or Deer mice
(Intergradation and extreme variation make identification of species very difficult. Only the more common and widely distributed species are included in this key.) 132.

131. Tail slightly more than one-third of total length; Utah to California and Texas, and southwards into Mexico
Onychomys torridus (Coues) Coues Grasshopper Mouse
Tail one-third or less of total length; western Minnesota south and west
Onychomys leucogaster (Wied) Grasshopper Mouse, Scorpion Mouse (Many subspecies)

132. With five tubercles on sole of hind foot; total length seven and one-half to nine inches; Florida
Peromyscus floridanus (Chapman) Florida White-footed Mouse
With six tubercles on sole; if from Florida, less than seven and one-half inches in total length 133.

133. Ears just the same color as the body; abdomen tinged with the same color as the upper parts; southeastern states

Peromyscus nuttalli (Harlan) Golden Mouse

Ears darker than back, usually edged with whitish; under parts white 134.

134. Upper grinding teeth, from side view, not showing small tubercles between the large ones; no nipples between the fore limbs, two pairs between the hind limbs; west of the Rockies and in western Texas 135.

Upper grinders with small tubercles between the large ones; with a pair of nipples between the fore limbs and two pairs between the hind limbs; generally distributed 137.

135. Total length nine to eleven inches; coast of California

Peromyscus californicus (Gambel) Parasitic Mouse

Total length six and one-half to eight inches 136.

136. Tail with a distinct tuft of hair at the tip; Oregon to Colorado and southwards

Peromyscus crinitus (Merriam) Canyon Mouse

Tail without evident tuft of hair at the tip; Utah to California and Texas, and southwards into Mexico

Peromyscus eremicus (Baird) Desert Mouse

137. Sole of hind foot all haired, except the toe pads; generally distributed

Peromyscus maniculatus (Wagner) Prairie Deer Mouse (Many subspecies)

Distal half of sole of hind foot naked 138.

138. Hair on under side white to roots; found only in Florida, Georgia and Alabama

Peromyscus polionotus (Wagner) Pigmy Peromyscus

Hair on under side darker at roots 139.

139. Tail usually not over three inches long, or less than one-half of total length 140.

Tail usually from three to four and one-half inches long, as long as or longer than the head and body 141.

140. Not found north of southern Virginia and southern Illinois; tail not distinctly bicolor

Peromyscus gossypinus (Le Conte) Cotton Mouse

From Canada to Louisiana; tail distinctly bicolor

Peromyscus leucopus (Raf.) Forest Deer Mouse

141. Tail about equal to head and body; eastern Oklahoma and Texas east to the Atlantic; southern Ill. and Virginia southwards

Peromyscus gossypinus (Le Conte) Cotton Mouse

Tail slightly longer in proportion to head and body; Arkansas to California; Oregon to Mexico 142.

142. Ear large, as long as hind foot

Peromyscus truei (Shufeldt) Big-eared White-footed Mouse

Ear smaller, not as long as the hind foot 143.

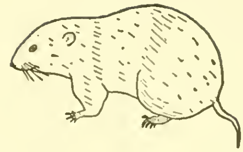
143. With dusky markings on "ankle" or tarsal joint

Peromyscus boylii (Baird) Boyle White-footed Mouse

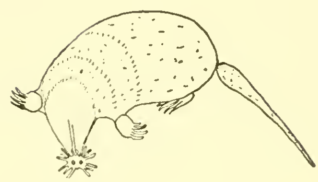
No dusky markings on tarsal joint

Peromyscus pectoralis (Osgood) Lacey White-footed Mouse

FLYING SQUIRREL



MEADOW MOUSE
OR VOLE



STAR-NOSED MOLE

WHITE-FOOTED MOUSE

PACK RAT

SHORT-TAILED SHREW

144. Tail flattened laterally and very sparsely haired; hind feet very large and partly webbed; getting to be one and one-half to two feet in total length; generally distributed
Ondatra zibethica (Linn.) Muskrat
(*Fiber zibethica* (Linn.))
Tail either cylindrical or else flattened and bushy; hind feet not webbed nor especially large 145.

145. Total length of adult nine or more inches; tail more than three times as long as the hind foot 146.
Total length of adult seldom reaching nine inches; tail shorter than the above in most, but not all, species 157.

146. Ears short, with the apertures almost hidden in the fur; tail scaly, sparsely haired 147.
Ears large and plainly visible; tail scarcely scaled Wood Rats or Pack Rats 149.

147. With short, soft under fur and longer shining guard hairs; tail blackish; in sphagnum bogs in Florida
Neofiber alleni True Florida Round-tailed Muskrat
With rough, loose pelage; tail dark above, lighter below; southern Atlantic and Gulf states and along the Mexican border 148.

148. Under parts white or grayish-white; southern states
Sigmodon hispidus Say and Ord Cotton Rat
Under parts buff; New Mexico and Arizona
Sigmodon minimus Mearns Little Cotton Rat

149. Tail flattened and bushy; from the Dakotas, Nebraska and Kansas westward
Neotoma cinerea (Ord) Bushy-tailed Wood Rat, Pack Rat
Tail cylindrical, not bushy 150.

150. First upper grinding tooth only about one-third longer than the last, the last grinder with four loops; hind feet dark colored; Pacific region
Neotoma fuscipes Baird Dusky-footed Wood Rat
First grinder fully twice as long as the last, the last with three loops; hind feet light colored 151.

151. East of the Mississippi River 152.
West of the Mississippi River 153.

152. Tail white below, well haired; in the Appalachian Mountain region from N. Y. to Ala.
Neotoma magister Baird Pennsylvania Wood Rat
(*Neotoma pennsylvanica* Stone)
Tail brownish below, sparsely haired; S. C. to Fla. and westward to Colo.; northward in the Mississippi Valley to Ill.
Neotoma floridana (Ord) Florida Wood Rat

153. Total length about fifteen inches; in the southern states westward to Texas, and northward to S. D.
Neotoma floridana (Ord) Florida Wood Rat
Smaller; in the southwestern states, eastward to Texas 154.

154. Tail almost the same color above and below; usually under twelve inches in total length; N. M. into Cal.

Neotoma lepida Thomas Desert Wood Rat

Tail much lighter below; often over twelve inches long 155.

155. White fur on throat, breast and groin lead colored at base; southward from Colo.

Neotoma mexicana Baird Mexican Wood Rat

White fur on these regions white at base 156.

156. Tail grayish-brown above; Colo. and Kansas southward through N. M. and Texas

Neotoma micropus Baird Texas Wood Rat

Tail blackish above; Colo. to Texas, and westward to Cal.

Neotoma albigula Hartley White-throated Wood Rat

157. Front of upper incisors each with a lengthwise groove near the outer edge Lemming Mice 158.

Upper incisors not grooved 159.

158. With a few brightly colored hairs at the base of each ear; with eight nipples; last two lower molars on each side each with three closed loops or triangles; northern New England and Washington state

Synaptomys borealis (Richardson) Canadian Lemming Mouse

No light colored hairs at the base of the ears; with six nipples; last two lower molars on each side each with four closed loops or triangles; eastern and central states

Synaptomys cooperi Baird Lemming Mouse

159. With a reddish dorsal band from the crown of the head to the root of the tail; molar teeth each with two small roots in adult specimens Red-backed Mice 160.

Without a reddish dorsal band 162.

160. In the northern states and southward in the mountains; dorsal band usually well defined

Clethrionomys gapperi (Vigors) Gapper Red-backed Mouse (*Evotomys gapperi* (Vigors))

In the Pacific states; dorsal band merging into the color of the sides 161.

161. Tail about one-third total length; living on the ground

Clethrionomys californicus Merriam California Red-backed Mouse

Tail longer; living in trees 164.

162. Grinding teeth with pronged roots; Pacific States 163.

Grinding teeth without pronged roots; generally distributed 165.

163. Tail less than one-fourth total length; upper parts grayish; Pacific states

Phenacomys intermedius Merriam Mountain Lemming Mouse

Tail over one-third total length; upper parts brownish; in Oregon and Cal. 164.

164. Upper parts bright reddish-brown

Phenacomys longicaudus True Red Tree Mouse

Upper parts brown, mixed with black

Phenacomys albipes Merriam Coastal Lemming Mouse

165. Tail not over one and one-half times as long as the hind foot; skull flat and wide 166.

Tail more than one and one-half times as long as the hind foot; skull high and narrow (A difficult group, with many intergrading species and subspecies. A few common ones are given here.) Meadow Mice or Voles 169.

166. With eight mammae; western states

Lagurus curtatus (Cope) Short-tailed Meadow Mouse

(*Lemmiscus curtatus* (Cope))

(Several subspecies, including *pallidus* (Merriam), *paupererimus* (Cooper) and *intermedius* (Taylor))

With four mammae or nipples, all between the hind legs 167.

167. West of the Mississippi River from Okla. to Iowa

Pitymys nemoralis (Bailey) Western Pine Mouse

(Considered to be a subspecies of *P. pinetorum*)

East of the Mississippi 168.

168. From Mass. to Ga.; upper parts chestnut; feet grayish

Pitymys pinetorum (Le Conte) Eastern Pine Mouse

In Florida; upper parts paler; feet pinkish

Pitymys parvulus Howell Florida Pine Mouse

169. With five plantar tubercles (raised pads on sole of hind foot) 170.

With six plantar tubercles 173.

170. Mammae (nipples) eight; Pacific states

Microtus oregoni (Bachman) Oregon Vole

(Includes *M. bairdi* Merriam and *M. serpens* Merriam)

With four or six mammae 171.

171. In Louisiana

Microtus ludovicianus Bailey Louisiana Meadow Mouse

In the plains states 172.

172. Total length of adult about five inches; N. D. and Minn.

Microtus minor (Merriam) Least Upland Vole

(*Pedomys minor* (Merriam))

Total length of adult about six to seven inches; most of the plains states

Microtus ochrogaster (Wagner) Prairie Vole

(Includes *M. haydenii* (Baird))

173. Middle upper molar with four closed triangles and a posterior loop; widely distributed, westward to the Rockies and into Washington

Microtus pennsylvanicus (Ord) Common Meadow Mouse, Vole

Middle upper molar without a fifth loop or triangle 174.

174. With two pairs of mammae, one between the front legs, the other between the hind legs; Ariz. to Texas

Microtus mexicanus (Saussure) Mexican Vole

With four pairs of mammae 175.

175. Snout yellowish; usually also yellowish around the ears and the rump; eastern states

Microtus chrotorrhinus (Miller) Rock Vole
Snout not distinctly yellowish; western states 176.

176. Total length about five to six inches; tail short, less than one-third total length 177.
Total length about seven to nine inches; tail about one-third total length 178.

177. Color above grayish; ears small, almost concealed by the fur; Rocky Mountain and Pacific states
Microtus montanus (Peale) Mountain Vole
Color above brownish; ears plainly visible; Cal. and Oregon
Microtus californicus (Peale) California Vole

178. Tail blackish, scarcely lighter below; Pacific states
Microtus townsendii (Bachman) Townsend Meadow Mouse
Tail gray below 179.

179. Total length of adult over eight inches; brown above; southward to Colo.
Microtus richardsoni (De Kay) Water Rat
Total length of adult seven to eight inches; grayish-brown above, often with a brighter mid-dorsal area; generally distributed over the western states
Microtus longicaudus (Merriam) Long-tailed Meadow Mouse
(Includes *M. mordax* (Merriam))

KEY TO THE SKULLS OF THE PRINCIPAL GENERA OF MAMMALS

1. With no incisor or canine teeth, and with cheek teeth peg-like
Dasypus Armadillo
With incisors, *or* with cheek teeth showing definite grinding surfaces — if skull is less than four inches long, take choice 15; if longer, take 2.

2. With no upper incisors; often with knobs, horns or antlers on frontal bones (above the orbits); cheek teeth with crescents on grinding surface 3.
Upper incisors present; never with horns or antlers 12.

3. Skull about two feet long, broad and flattened on top 4.
Smaller, rarely over eighteen inches long; cranium rounded and usually widest just behind the orbits 6.

4. Parietal bone showing only on back of skull; space from tip of upper jaw to tip of nasals only about one-fifth of total length, tip of nasals coming above a point halfway between tip of jaw and first cheek teeth
Bos Cow
Parietal bone showing on top of skull; space from tip of upper jaw to tip of nasals about one-third of total length of skull, tip of nasals coming above the first cheek teeth 5.

5. Width of head between orbits more than half the length of the skull; horns present
Bison Buffalo
Width of head not much more than one-third the length; males with palmate antlers during most of year
Alce Moose

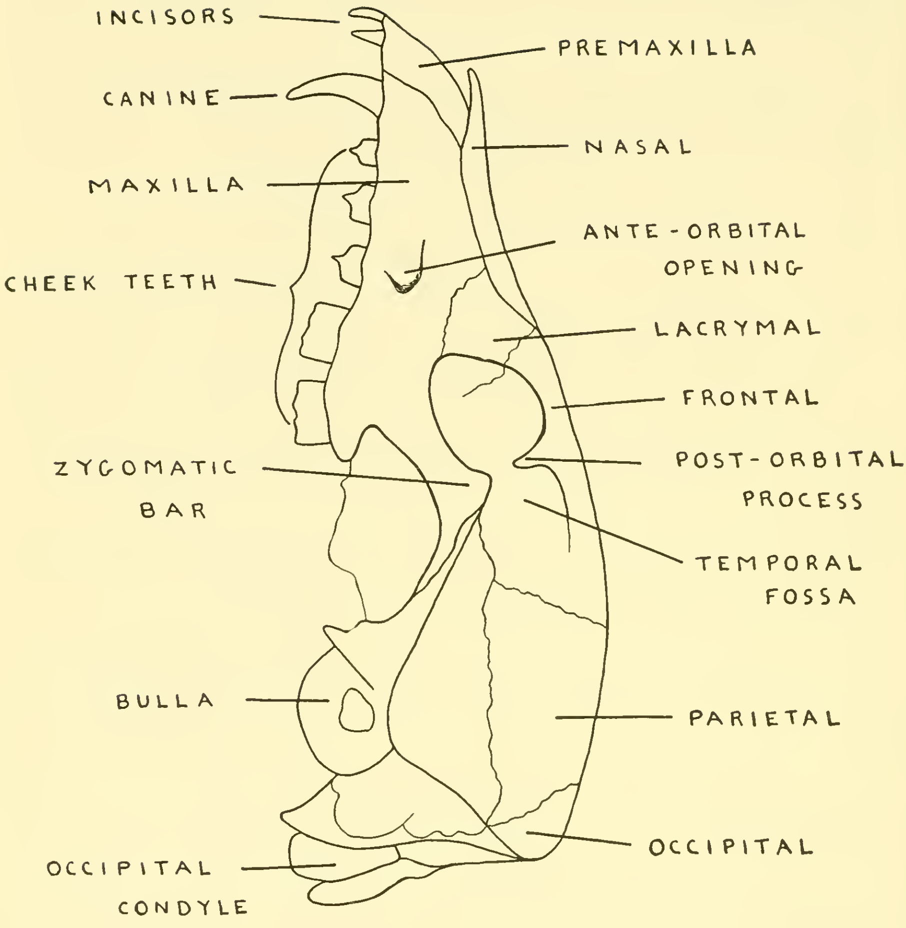


DIAGRAM OF THE SKULL

OF A MAMMAL

6. Skull about eighteen inches long, with large upper canines; space from front of jaw to tip of nasals less than one-fourth the total length of the skull
   Cervus Elk or Wapiti
   Skull smaller, without above combination of characters; canines, if present, very small 7.

7. Skull about fifteen inches long; small upper canines often present; with antlers or stubs in both sexes; tip of nasals above first cheek teeth
   Rangifer Caribou
   Skull not over twelve inches long; upper canines rare; tip of nasals not as far back as first cheek teeth 8.

8. Frontal bone with a fairly even margin over orbit 9.
   Frontal bone with a definite notch or notches over front part of orbit 10.

9. Orbit circular; horn, if present, rising almost vertically above most of orbit; lacrimal bone without depression on outer face
   Antilocapra Pronghorn
   Orbit slightly longer than high; antlers, if present, rising behind orbit almost parallel with the frontal; lacrimal with a definite hollow on outer surface
   Odocoileus White-tailed and Black-tailed Deer

10. Horn cores circular in cross section; frontal region flat or concave between orbits; nasals not extending as far back as level of front of orbits
    Oreamnos Mountain Goat
    Horn cores, when present, triangular or long-oval in cross section; frontal definitely convex between orbits; nasals extending as far back as orbits 11.

11. Marked depression on face of lacrimal; nasal convex; little or no gap between lacrimal and nasal; anterior slope of skull about twice as long as the posterior slope; horn triangular at base
    Ovis Sheep
    No depression on face of lacrimal; nasal concave posteriorly; large gap between lacrimal and nasal; anterior slope of skull about as long as posterior slope; horn long-oval at base
    Capra Goat

12. Skull six to twelve inches long; back of cranium high and squared off; canine teeth present, molars with several cusps 13.
    Without the above combination of characters 14.

13. Six upper incisors; upper canines extending sideways
    Sus Pig
    Four upper incisors; upper canines directed downward; a deep notch in side of upper jaw to receive lower canine
    Pecari Peccary

14. Skull about two feet long; cheek teeth almost square and with complex folds of enamel shown on grinding surface
    Equus Horse
    Rarely more than twelve inches long 15.

15. Canine teeth present 16.
    No canines; a wide gap between incisors and cheek teeth (Rodents) 57.

16. Incisors 10/8; two large oval openings in palate between cheek teeth; very small brain case with large occipital crest
Didelphis Opossum
With less incisors; palatal openings, if any, small 17.

17. Canine teeth about twice as long as others; incisors small (Carnivores) 18.
Canines little, if any, larger than other teeth, *or* very small skulls with a gap in front part of upper jaw 42.

18. Skull almost as wide (from one zygomatic arch to the other) as long; post-orbital bar almost complete; cheek teeth 4/3 or 3/3 (Cat Family) 19.
Skull length one and one-half times, or more, the zygomatic width; post-orbital bar quite incomplete; more cheek teeth usually present 20.

19. Maxilla making contact with one-half the length of nasal; four upper cheek teeth (first and fourth very small) on each side
Felis Cat, Panther
Maxilla making only slight contact with nasal; three upper cheek teeth on each side
Lynx Lynx and Bobcat

20. Ear canal opening directly to side of skull; inner part of last cheek tooth not markedly wider than outer part; most animals in this group with a skull four inches or more in length 21.
Ear canal slanting forward; inner part of last cheek tooth definitely wider than its outer part; usually small skulls, rarely over four inches long Weasel Family 33.

21. Teeth all relatively small, cheek teeth peg-like or with three points, and of less diameter than the canine tooth; outer incisors definitely larger than the inner Seals and Sea-lions 22.
Teeth of good size, at least three of the back cheek teeth touching their neighbors and with well developed cutting or grinding surfaces; incisors not differing greatly in size 25.

22. Cheek teeth set diagonally in jaw, small and with three points; upper incisors pointed; cranium very wide and flat
Phoca Harbor or Hair Seal
Cheek teeth not definitely three pointed; upper incisors notched; cranium sometimes with a ridge on top 23.

23. Nose pointed; cheek teeth almost or quite touching; males with a very high crest on cranium
Zalophus Sea Lion
Nasal region high, giving the skull a rectangular appearance when viewed from the side; cheek teeth not touching 24.

24. Fifth upper cheek tooth separated by about three-quarters of an inch from the fourth
Eumetopias Northern Sea Lion
Upper cheek teeth evenly spaced
Callorhinus Fur Seal

25. Skull usually ten inches or more in length; nasal bones not touching the maxillary bones Bear Family 26.

Skull usually under five inches in length, unless with the back cheek teeth provided with cutting, rather than grinding, surfaces; nasals usually making some contact with maxillaries 27.

26. Profile convex; skull of adult about ten inches long
Ursus americanus Black Bear

Profile slightly concave; skull of adult about fourteen inches long
Ursus horribilis Grizzly Bear

27. Top profile convex in front of eye region; the large upper teeth with grinding surfaces; opening on side of nose (ante-orbital foramen) less than its own diameter from the edge of eye socket Raccoon Family 28.

Profile at least slightly concave on nose region; the longest upper cheek tooth modified for cutting or shearing; ante-orbital foramen more than its own diameter from edge of eye socket 29.

28. Palate extending far behind level of last cheek teeth; foramen magnum definitely wider than high; skull usually about four inches long
Procyon Raccoon

Palate ending at level of last cheek tooth; foramen magnum almost circular; skull about three inches long
Bassariscus Ring-tail Cat

29. Postorbital process slightly hollowed out on top; incisors without small side tubercles at gum level; profile almost straight 30.

Postorbital process slightly convex on top; incisors with small tubercles at gum level; profile concave 31.

30. Crests coming almost together at fronto-parietal suture and continuing posteriorly almost in contact
Vulpes Red Fox

Crests ¾ inch or farther apart at fronto-parietal suture, not joining until parietal-occipital suture
Urocyon Gray Fox

31. Skull markedly concave in front of orbits; largest upper cheek tooth with a low rounded inner projection
Canis familiaris Dog

Skull slightly concave in front of orbits; largest upper cheek tooth with a well developed inner cusp 32.

32. Eight and one-half to eleven and one-half inches long; cranium as high as wide
Canis lupus and relatives Wolves

Rarely over seven and one-half inches long; cranium wider than high
Canis latrans and relatives Coyotes

33. Widest part of skull at rear; bulla rounded; cheek teeth 4/5; skull about five inches long
Taxidea Badger

Not with above combination of characters 34.

34. Skull three inches or longer; usually with five upper cheek teeth, the first very small 35.

Skull less than three inches; three or four upper cheek teeth 38.

35. Skull almost flat in upper profile; four or five lower cheek teeth; last two upper cheek teeth as wide as, or wider than, long 36.

Skull somewhat convex in upper profile; six lower cheek teeth; next to last upper cheek tooth definitely longer than wide 37.

36. Six lower incisors; skull about four inches long, greatest width less than 2/3 the length

Lutra Otter

Four lower incisors; skull about five inches long, greatest width 2/3 the length; West Coast; rare

Enhydra Sea Otter

37. Palate reaching one-third of the distance between last molar and bulla; narrowest part of skull just behind orbits

Martes Marten and Fisher

Palate reaching half way between last molar and bulla; narrowest part of skull middle of temporal fossa

Gulo Wolverine

38. Skull almost flat on top; palate extending well beyond the back of last molars 39.

Skull highest in frontal region; palate ending in line with, or slightly behind, back of last molars 40.

39. Bulla flattened; ante-orbital opening scarcely visible from dorsal view; skull about two and one-half inches long; zygomatic bar heaviest anteriorly

Mustela vison Mink

Bulla rounded; ante-orbital opening plainly visible from dorsal view; skull usually less than two inches long; zygomatic bar weakest anteriorly

Mustela Weasels

40. Bulla well rounded; next to last upper molar elongate-oval

Spilogale Spotted Skunk

Bulla flattened; next to last upper molar triangular 41.

41. Palate ending at level of back of last molars; four upper cheek teeth on each side, the first very small

Mephitis Common Skunk

Palate extending almost as far behind the level of the back of last molars as the length of those teeth; three upper cheek teeth

Conepatus Hog-nosed Skunk

42. Teeth chestnut-colored; no zygomatic bar 43.

Teeth not reddish; a fragile bar present 44.

43. Teeth behind the large incisor with first and second large and of almost equal size, third and fourth much smaller and about equal, fifth minute

Blarina Short-tailed Shrew

The third tooth (as counted above) not much smaller than the second

Sorex Long-tailed Shrew

44. Premaxilla without palatal or ascending processes, leaving a gap in the front of the upper jaw, *or* with only two incisors between the much longer canines 45.

No such gap; front pair of teeth larger than the next three or four 54.

45. One minute incisor before each upper canine 46.
Two minute incisors before each upper canine 50.

46. Four upper cheek teeth on each side 47.
Five upper cheek teeth 48.

47. Incisors separated by less than the width of one; frontal region somewhat concave
Tadarida Free-tailed Bat
Incisors separated by about four times the width of one; frontal region convex
Lasiurus Red Bat and Hoary Bat

48. Profile convex; gap between tips of incisors less than width of incisor at base
Antrozous Pale Bat
Profile slightly concave before orbits; gap between incisors more than twice the width of incisor 49.

49. Length of skull only twice its height; upper incisor touching canine
Dasypterus Yellow Bat
Length of skull three times its height; upper incisor not touching canine
Nycticeius Rafinesque's Bat

50. Six upper cheek teeth on each side
Myotis House or Little Brown Bat
Four or five upper cheek teeth 51.

51. Four upper cheek teeth on each side
Eptesicus Brown Bat
Five upper cheek teeth 52.

52. Cranium high; skull length about twice the height
Corynorhinus Lump-nosed Bat
Profile fairly straight; skull length about two and one-half times the height 53.

53. Skull about three-fourths of an inch long; six lower cheek teeth on each side
Lasionycteris Silvery Bat
Skull seldom over one-half inch long; five lower cheek teeth
Pipistrellus Pipistrelle Bat

54. Bulla well developed; ten teeth in each half of upper jaw, eight below; anterior teeth, after the first, varied in size
Scalopus Common Mole
Bulla only slightly developed; eleven teeth above and below on each side, the anterior ones, after the first, about equal in size 55.

55. Profile slightly concave in frontal region; first upper incisor projecting anteriorly
Condylura Star-nosed Mole
Profile slightly convex; first upper incisor directed downwards 56.

56. Fourth upper tooth on each side almost as long as the first; bulla scarcely evident; no auditory meatus (bony tube to ear)
Parascalops Hairy-tailed Mole

Fourth upper tooth smaller than first and about equal to second and third; bulla present but depressed; short auditory meatus present
Scapanus Western Mole

57. Two tiny incisors behind the upper two large ones 58.
Only two upper incisors 60.

58. Skull not particularly high, not spongy before orbits; five upper cheek teeth on each side; no post-orbital processes
Ochotona Pika
Skull high, spongy before orbits; six upper cheek teeth on each side, last one very small; post-orbital processes present 59.

59. A more or less diamond-shaped bone (inter-parietal) between parietals and supra-occipital; post-orbital processes diverging from cranium
Lepus Jack Rabbit and Domestic Rabbit
No inter-parietal evident in adult; post-orbital processes lying close to cranium, leaving only a slight notch
Sylvilagus Cottontail Rabbit

60. With distinct post-orbital processes; very small ante-orbital opening (Squirrel Family) 61.
No definite post-orbital processes; ante-orbital opening large or small 72.

61. About three and one-half inches long; skull flattened on top, concave between orbits; post-orbital process with posterior edge at right angles to median line of skull; incisors about as wide as deep
Marmota Woodchuck
Smaller; skull convex; post-orbitals directed posteriorly; incisors narrow and deep 62.

62. Ante-orbital opening a vertical slit 63.
Ante-orbital opening oval or triangular 65.

63. Skull about one and three-quarters inches long; nasals one-fourth the length of the skull
Tamiasciurus hudsonicus Red Squirrel
Skull about two and one-half inches long; nasals one-third the length of the skull 64.

64. Five cheek teeth above on each side, the first small and sometimes lost
Sciurus carolinensis (and relatives) Eastern Gray Squirrel
Four upper cheek teeth
Sciurus niger (and relatives) Fox Squirrel

65. Zygomatic bar, as seen from above, following the curve of the skull 66.
Zygomatic bar, as seen from above, projecting decidedly from side of cranium 68.

66. A definite notch in middle of upper rim of orbit
Glaucomys Flying Squirrel
Notch, if present, not in middle of upper rim of orbit 67.

67. Four upper cheek teeth on each side, the rows converging posteriorly
Tamias Eastern Chipmunk
Five upper cheek teeth, the rows parallel
Eutamias Western Chipmunk

68. About two and one-half inches long; upper cheek teeth converging posteriorly; narrowest part of palate between last teeth; incisors whitish
Cynomys Prairie-dog
Seldom over one and three-fourths inches; upper cheek teeth almost parallel; incisors yellow or orange 69.

69. Width of nasals only about one-third of the distance between orbits 70.
Width of nasals about one-half or more of the distance between orbits 71.

70. Total length of skull about one and one-half inches
Citellus (*Ammospermophilus*) Antelope Ground Squirrel
Total length of skull about two inches
Citellus (Otospermophilus) Rock Squirrel

71. Nasals tapering posteriorly
Citellus (*Callospermophilus*) Say's and Mantled Ground Squirrel
Nasals scarcely tapering posteriorly
Citellus Ground Squirrel

72. Cheek teeth on opposite sides of jaw converging and almost meeting anteriorly; palate between molars abruptly lower than the anterior portion (step-like) 73.
Cheek teeth in almost parallel rows; palate usually on one level or smoothly sloping 75.

73. Skull two and one-half inches long; incisors white; molars sharply angled on sides
Cavia Guinea-pig
Skull four to five inches long; incisors orange; cheek teeth not sharply angled on sides 74.

74. Space between orbits considerably wider than nasals; ante-orbital opening so large as to appear like an orbit
Erethizon Porcupine
Space between orbits about equal to width of nasals; ante-orbital opening small
Castor Beaver

75. Skull about two and one-half inches long and compressed to a ridge between orbits; ante-orbital opening large; incisors orange
Ondatra Muskrat
Not with the preceding combination of characters 76.

76. Cheek teeth with rounded tubercles, in two or three rows 77.
Cheek teeth with plane surfaces or with enamel folds forming open or closed triangles (young animals may appear to have rounded tubercles but rarely in rows) 85.

77. Upper incisors grooved; skull seldom over one inch long 78.
Upper incisors not grooved; skull from $3/4$ to $1\frac{1}{2}$ inches long 80.

78. Bullae much enlarged, forming bulges on the back corners of the skull; Dakotas and Neb. westward
Perognathus Pocket Mouse
Bullae normal, not visible from above; generally distributed 79.

79. Ante-orbital opening long oval; four upper cheek teeth; Canada and northern half of U. S.

Zapus Jumping Mouse

Ante-orbital opening narrowing to a slit below; three upper cheek teeth; southern half of U. S.

Reithrodontomys Harvest Mouse

80. With a thread-like ridge along upper rim of eye-socket 81.
No such ridge 83.

81. Skull rarely as much as $1\frac{1}{4}$ inches long; cheek teeth with two rows of cusps; large opening in palate near last upper cheek tooth, the latter showing one posterior and two or more anterior planes

Oryzomys Rice Rat

Skull usually from $1\frac{1}{4}$ to $1\frac{3}{4}$ inches long; cheek teeth with three irregular rows of cusps; none or a very small opening in palate near last upper cheek tooth, this tooth usually having one large surface with one smaller inner and slightly anterior one 82.

82. Cheek tooth row almost as long as the space between incisor and beginning of cheek tooth row; skull usually about $1\frac{1}{2}$ inches long

Rattus rattus Black Rat, Roof Rat

Cheek tooth row about one-half as long as the space between it and the incisor; skull usually about $1\frac{3}{4}$ inches long

Rattus norvegicus Barn, Gray or Norway Rat

83. Cheek teeth with tubercles in three irregular rows; skull about $\frac{3}{4}$ inch long and very delicate

Mus musculus House Mouse

Cheek teeth tubercles in two rows; skull 1 to $1\frac{1}{2}$ inches long; thin but not particularly delicate 84.

84. Last upper cheek tooth about one-half the size of the one before it; upper edge of orbit rounded; coronoid process of lower jaw (dorsal projection anterior to hinge) about as long as its width at base

Peromyscus White-footed or Deer Mouse

Last cheek tooth less than one-half the size of its neighbor; upper rim of orbit sharp-edged; coronoid process about twice as long as its width at base; Dakotas and Neb. west and south

Onychomys Grasshopper Mouse

85. Skull about $2\frac{1}{2}$ inches long, almost as wide as long; five upper cheek teeth on each side, each, after the first, with a definite projection on the outer side

Aplodontia Mountain Beaver

Skull smaller; not more than four upper cheek teeth on each side, the first sometimes 8-shaped and easily mistaken for two 86.

86. Three upper cheek teeth on each side, each sometimes with several lobes and so appearing to be more 87.
Four upper cheek teeth, the first sometimes very small 95.

87. Upper incisors grooved on anterior surface 88.
Upper incisors not grooved 89.

88. Incisor groove near outer edge of incisor; nose short, its length (to be-

ginning of cheek-bone arch) one-fourth the total skull length
Synaptomys Lemming Mouse

Incisor groove in center of face of incisor; nose about one-third of length of skull
Napaeozapus Woodland Jumping Mouse

89. Enamel folded on first cheek teeth in definite pattern of letter S; southern states
Sigmodon Cotton Rat

Enamel folds not particularly S-shaped 90.

90. Palate extending to or behind level of last cheek teeth; cheek teeth with two irregular rows of cusps; southern states
Oryzomys Rice Rat

Palate not extending as far back as the level of back of last cheek teeth; cheek teeth with open or closed enamel triangles 91.

91. Cheek teeth each with two small roots (in adult); embedded end of lower incisor begins just anterior to a small opening near back of jaw and just posterior to root of last cheek tooth; northern states 92.

Cheek teeth of same diameter throughout length; embedded end of lower incisor longer, running almost to back of jawbone; generally distributed 93.

92. Distinct raised line or ridge over top of eye-socket and extending back on braincase; cheek teeth large, the upper about one-half as wide as the space between tooth rows; Canada, Rockies and West Coast in mountains
Phenacomys Tree Mouse, Lemming Mouse

Skull delicate, no ridge over eye-socket; cheek teeth small, the upper about one-fourth as wide as the space between tooth rows; northern states
Clethrionomys (*Evotomys*) Red-backed Mouse

93. Zygomatic width about one-half the length of the skull; skull about two inches long
Neotoma Wood Rat

Zygomatic width definitely more than one-half the length of skull; skull about one inch long (except in one large Florida species) 94.

94. Skull about one inch long; length about one and two-thirds the zygomatic width
Microtus Meadow Mouse

Skull smaller, barely over $3/4$ inch; short and wide, length one and one-half times the width
Pitymys Pine Mouse

95. Bullae so large as to be visible from above 96.

Bullae not extreme, not visible from above 98.

96. Each cheek tooth with a U-shaped enamel fold
Perognathus Pocket Mouse

Cheek teeth each with a simple outer margin of enamel 97.

97. Maxilla with a large triangular projection before each orbit; each cheek tooth with a complete outer ring of enamel

Dipodomys Kangaroo Rat

Maxilla without projecting wing before orbit; last upper cheek tooth with a gap in the outer ring of enamel

Microdipodops Dwarf Pocket Rat or Pocket Mouse

98. Nasals extending well beyond incisors; skull about one inch long; cheek teeth with infoldings of enamel which may make teeth appear to have several cusps

Zapus Jumping Mouse

Nasals extending only slightly, if at all, beyond incisors; skull about two inches long; no infoldings of enamel 99.

99. Upper incisors smooth or with a shallow groove near inner edge

Thomomys Western Pocket Gopher

Groove almost in center of incisor face, or with two grooves, the deeper one toward the outer edge 100.

100. With one groove almost in the middle of each upper incisor; two middle upper cheek teeth with enamel plates on anterior side only

Cratogeomys Chestnut-faced Pocket Gopher

With two grooves in each upper incisor, the deeper one toward the outer edge; upper cheek teeth with enamel on both anterior and posterior sides

Geomys Eastern Pocket Gopher

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EGGS

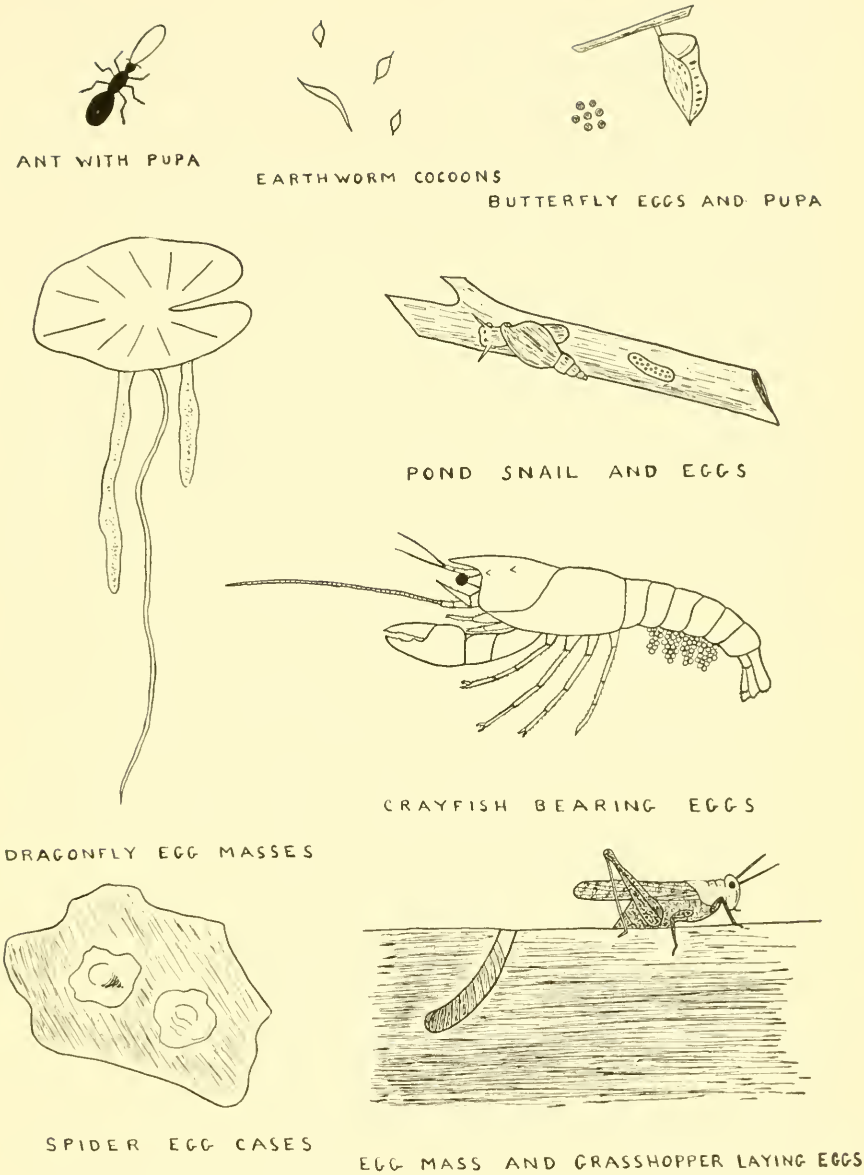
CHAPTER 16

Most of us no longer trouble ourselves over the old problem as to which came first, the hen or the egg, but in our trips afield we may frequently wonder just what animals are likely to hatch from the eggs we may find, since not only the hen but all birds, turtles, many snakes, lizards, salamanders, frogs, fish and many invertebrates lay fairly conspicuous eggs. The first indications as to the possibilities of a strange egg are the habitat in which it occurs and the nature of its outer covering. Size, shape, color and deposition singly or in bunches all furnish additional clues.

Eggs laid in water are almost invariably covered with a gelatinous coat or coats, which serve as protection against hungry animals and as a means of concentrating heat to speed up development. By means of this greenhouse construction it is possible for eggs to develop, even though the pond be full of floating ice. The eggs most likely to attract attention are those of fish and amphibians. Other eggs commonly found in water are those of arthropods, especially insects, and of mollusks. The invertebrate eggs are usually individually smaller than those of water vertebrates, although the egg masses may be quite conspicuous.

Fish eggs are found in groups of many separate eggs, or in bunches or masses. In general fish eggs may be recognized by a uniformly milky or iridescent appearance without conspicuous, supplementary, jelly envelopes, so that they resemble a mass of boiled tapioca. Some fishes lay colored eggs, those of the carp, for example, being red and those of the sturgeon being various shades of brown. Fish eggs are often deposited in a nest or circular depression in the pond or stream floor or in a hollow in the bank or under a sunken log. Usually the male parent is close by to guard the nest. Many trout bury many separate eggs in gravel or under small stones. The perch and pickerel lay in shallow water among twigs or water weeds and deposit strings of many eggs in close zigzag or spiral arrangement. A few fishes, such as the sticklebacks, build elaborate nests, much like those of birds, among the water weeds.

Salamander eggs are laid either singly or in masses. Most of the *Ambystomidae* lay bunches of dark-colored eggs with one or more envelopes around each indivdual egg and with a common jelly envelope around the whole mass. They may be distinguished from frog eggs by means of this common envelope, which is not characteristic of the latter. Most of the *Ambystoma* group lay in early spring, many of them while the ponds are still full of floating ice, attaching the egg masses to sticks and water plants a few inches below the

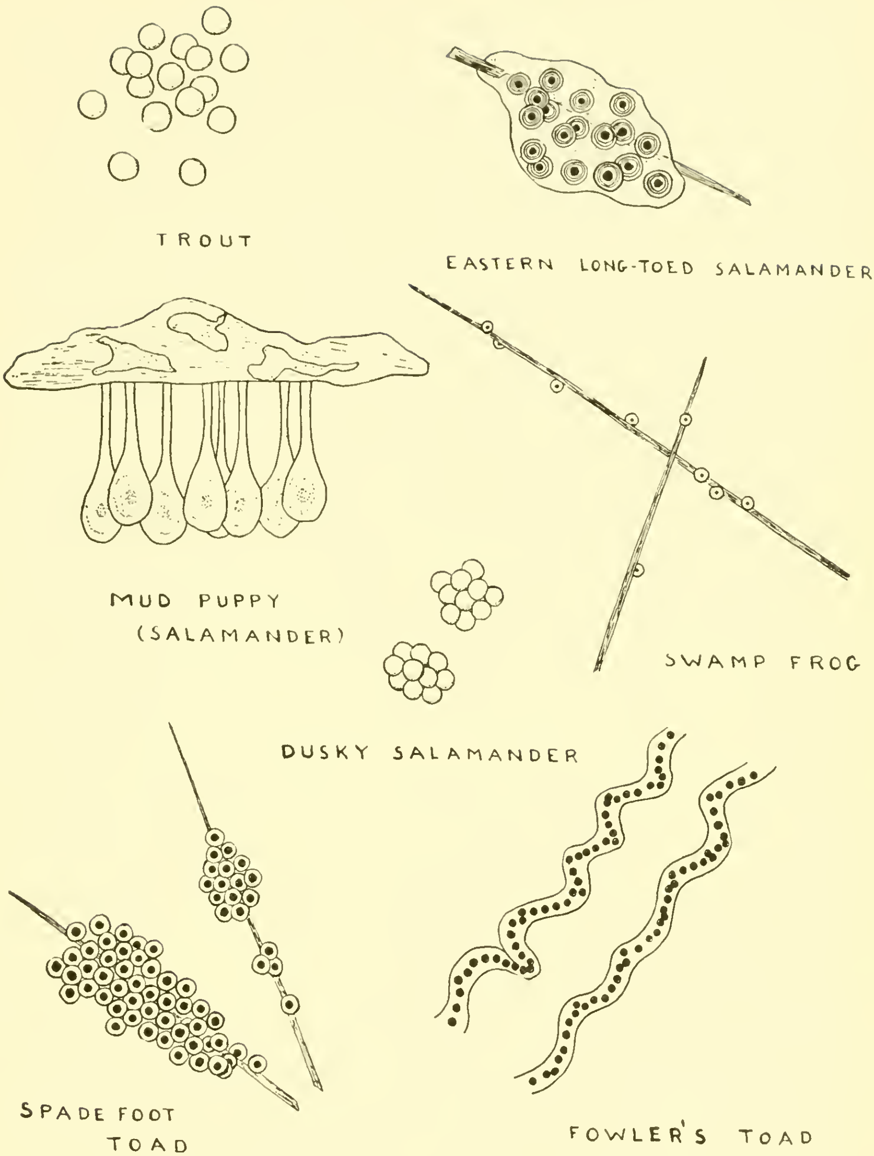


INVERTEBRATE EGGS, PUPAE ETC.

surface of the water. Whitish, cone-shaped objects about one-half an inch high and a quarter of an inch across at the base may often be seen on submerged vegetation. These are the spermatophores left by the males to be picked up by the females. Many of the family *Plethodontidae* attach their eggs to the under sides of stones at the edges of small mountain streams. The unpigmented eggs are attached by slender stalks and may occur singly or in small, grape-like bunches. The newts are not uniform in their breeding habits, the western or giant California newt, *Triturus torosus,* attaching small masses of pigmented eggs to sticks and vegetation, while the common newt, *Triturus viridescens viridescens,* wraps each egg separately in the rolled leaf of some water plant. The large water salamanders, the hell-bender and the Congo snake, lay groups of unpigmented eggs connected by slender strings of jelly. The mudpuppy suspends many unpigmented eggs separately from the under sides of submerged logs and rocks.

During most of the spring and summer one species or another of the frogs or toads is breeding. Most species have a limited mating season but a few, such as the spring peeper, *Hyla crucifer,* may be heard calling from early spring to midsummer. Most frogs' eggs are laid in bunches of many pigmented eggs with one or more jelly envelopes around each egg but without any common envelope around the whole mass. The wood frogs are usually the first to lay. Their eggs are often confused with those of the salamanders of the *Ambystoma* group but, unlike those of most salamanders and most of the other frogs, most of the bunches of wood frog eggs in a pond are often concentrated in one great, semi-floating mass. Meadow and upland frogs lay somewhat later, the meadow frog depositing masses of black and white eggs, while those of the upland frog are brown above and cream colored below. Green frogs and bullfrogs lay during the summer and produce floating sheets of eggs. The spring peeper and the cricket frog scatter their eggs singly among water weeds, so that they are very difficult to find and are rarely seen. The true toads lay long, curling strings of jelly containing pigmented eggs in serial arrangement.

Some invertebrate eggs are noticeable features of ponds and streams. Small plates of jelly on submerged logs and plants are likely to be snail eggs—usually a hand lens will enable one to see the tiny shells forming around the young snails in each mass. Some of the crustaceans, of which the crayfish is the most conspicuous example, carry bunches of gelatinous eggs attached to their abdomens. Insect eggs are infinitely numerous and varied. Many are deposited singly and are so small that they usually escape notice. Others are laid in groups, with or without gelatinous coverings. Long strings of jelly of the approximate diameter of strings of toad eggs, often encountered when one picks the blossoms of the white or yellow water lilies, are probably the egg masses of some of the dragonflies, the individual eggs appearing as brownish, irregularly scattered dots. (Many species of dragonflies deposit their eggs singly at the



FISH AND AMPHIBIAN EGGS

surface of the water.) Great clusters of hair-like strings of eggs in linear arrangement are apt to be midge egg-masses. Balls of jelly about the size of marbles and containing many minute eggs are likely to be the egg-masses of caddis flies. Occasionally in autumn great numbers of tiny objects resembling fig seeds may be found along the margins of lakes and ponds. These are not eggs but may be the gemmules of sponges or the statoblasts or reproductive units of Bryozoa. A sponge gemmule may be recognized by the tiny spines or spicules embedded in the outer wall. The statoblasts of the common Bryozoa are either smoothly margined or else bear a ring or rings of tiny hooks designed to anchor them in some safe harbor for the winter.

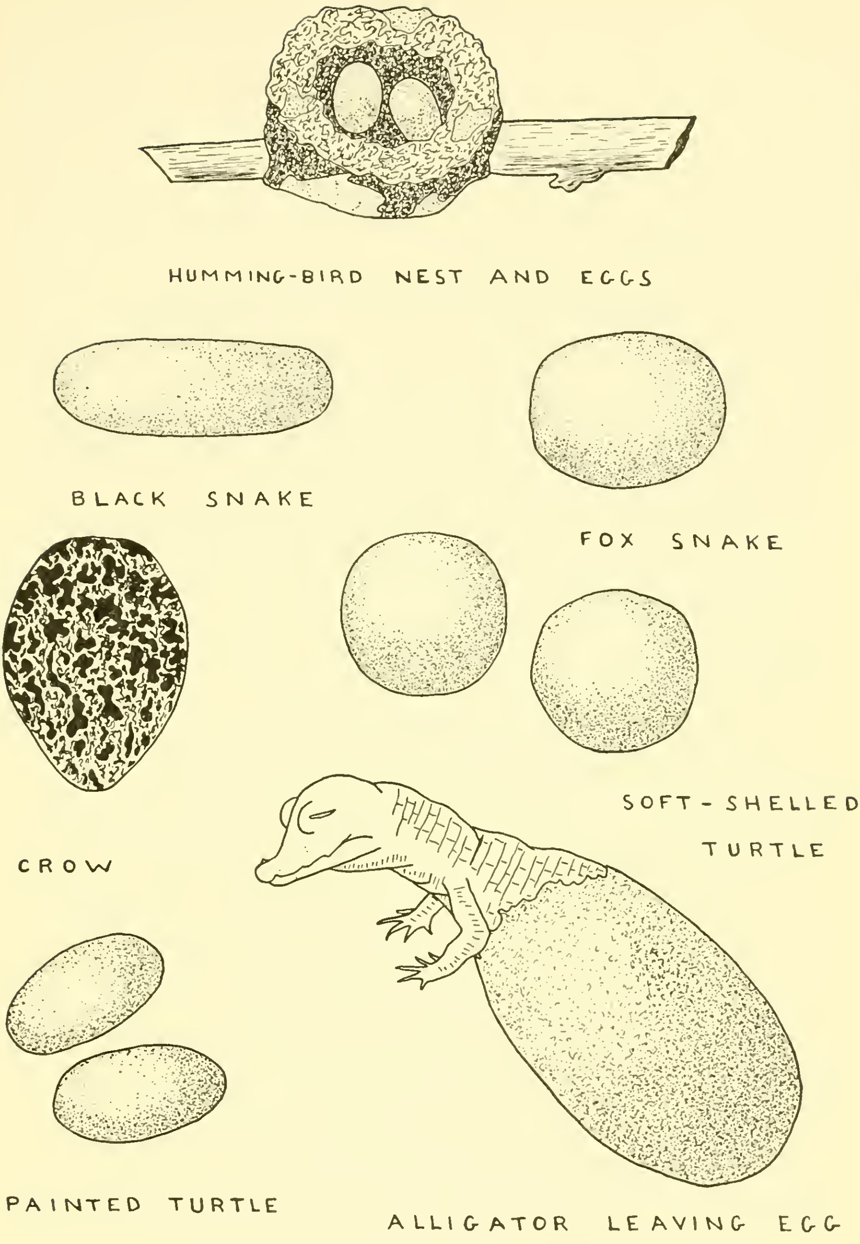
Eggs found on land may be identified by texture, color, size, shape and other characters. Gelatinous eggs, either singly or in bunches, are usually those of mollusks or amphibians. Eggs with tough outer coverings may be those of mollusks, arthropods, reptiles or birds, the invertebrate eggs usually being smaller than those of vertebrates. More detailed discussions of the eggs of the different groups follow.

Most terrestrial mollusks (snails and slugs) deposit separate eggs which may cling together in bunches. The eggs vary from spherical to elliptical shapes and may be hard-shelled or gelatinous. Many land mollusks deposit soft, milky eggs under boards or logs or on vegetation. *Helix* and related genera as well as some of the other land snails lay clusters of shelled eggs. One large tropical species lays oval, shelled eggs much like those of reptiles.

Arthropod, especially insect, eggs are so varied and numerous as to discourage description. A few generalities may be pertinent, however. Most of the eggs of this group are very small, shelled, and vary somewhat from simple oval or spherical shapes. Many are cylindrical or spindle-shaped, some have elaborate markings or flutings, and some open by tiny caps or lids. They may be found singly or in groups and may be white or colored. Structures often mistaken for eggs are the woven cocoons and the ornamented chrysalides or pupa cases of moths, butterflies and other insects. The common "ants' eggs" often purchased with the mistaken idea that they make good food for pet baby turtles are not eggs but ant pupae in their cases. Some arthropods, such as spiders, deposit groups of eggs within fibrous cases.

Most of the amphibians that lay their eggs on land are salamanders of the family *Plethodontidae*. They deposit unpigmented eggs either singly or in bunches in damp places under logs, stones or moss. In most species the female can be found with or near the eggs. One of the *Ambystomidae, Ambystoma opacum*, deposits bunches of pigmented eggs during the autumn under vegetation on the dry or semi-dry floors of temporary ponds.

Reptile eggs are either spherical or ovoid and vary from about the size of peas up to the size of golf balls or larger. They are usually white and have tough, leathery shells which can be torn but which do not readily crack. It is



REPTILE AND BIRD EGGS

usually impossible to distinguish between the eggs of snakes, turtles and lizards except by means of habitat, time of discovery and logical possibilities based on distribution and abundance of local species. Some snakes lay in manure piles or among rotting leaves where the heat of fermentation aids in incubation. Others lay under logs or under thin, flat stones that absorb and retain heat from the sun. Most egg-laying snakes produce ovoid eggs, although the eggs of a few snakes are almost spherical. The alligator lays eggs about the size and shape of goose eggs in piles of rotting vegetation in swamps. Most of the lizards bury their eggs and pay them no further attention. Some species of lizards deposit their eggs in rotting logs, damp moss or similar places and remain with them to help incubate or protect them. The turtles bury their eggs in warm, damp sand. The species of snapping turtles, mud and musk turtles, and the soft-shells lay spherical eggs. The eggs of most of the other turtles are ovoid.

Birds' eggs have limy shells that crack easily. In general birds that nest on the ground or in open nests have mottled or colored eggs, while those that nest in dark cavities of hollow trees, caves or chimneys lay white or pale eggs. Thus the bluebird, like other members of the thrush family, lays blue eggs, but in conformity with its habit of nesting in holes in trees its eggs are only faintly tinted with blue. Birds that build no nests but use a hollow on the ground or a depression in a rock usually lay eggs pointed at one end and therefore having less tendency to roll. Birds' eggs are most appealing from the aesthetic point of view but are not readily available for collection because of strict laws restricting the taking of eggs of most species. For purposes of study and identification, birds' eggs are very satisfactory because of definite specific sizes, color and markings. Unlike the eggs of most of the other groups, a great deal of information has been collected about the eggs of birds, and several good books are available about them.

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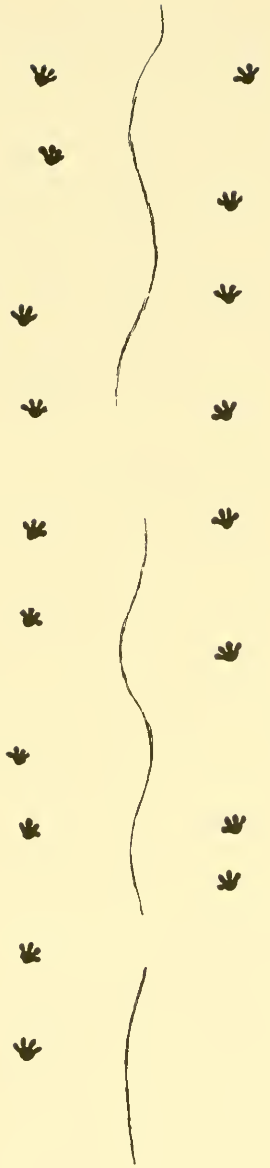
TRACKS

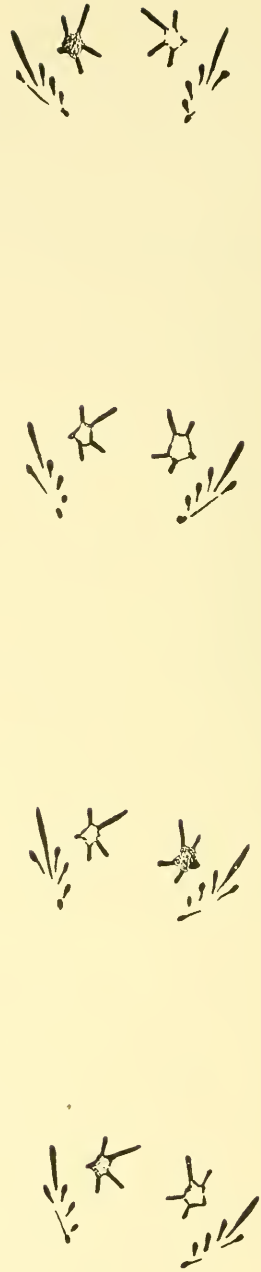
CHAPTER 17

The ability to recognize the tracks of our common animals adds considerably to the pleasure of our walks and increases our knowledge of the local fauna. Many of the wild animals have learned to avoid man and to make their excursions in the twilight of early morning and late evening, so that only by their tracks are we likely to become aware of their presence. In the winter a light snowfall will often take the record for us to read, while the rest of the year dusty hollows, such as are often found under overhanging rock ledges, and the banks of streams and ponds, as the waters recede after a flood or with the drought of summer, present the autograph album for our inspection. Like many human signatures, these animal tracks sometimes puzzle us at first but, since the same tracks are usually repeated many times, a few clear ones to show details will usually tell the story. The arrangement of footprints in a series is as important as the detail of the individual print in identifying the maker and in disclosing something of his normal habits. In the occasional good tracking snows of winter, an attempt to follow the track of some one animal, even if it be only the wide-ranging house cat, will teach one much about animal psychology. It is a surprise to most people to learn how many wild animals are holding their own, even on the outskirts of large cities. A booklet of the Field Museum lists thirty-nine species of wild mammals living within the Chicago area. In addition to mammals, there are hosts of birds and numbers of reptiles and amphibians, all leaving prints that he who walks may read.

One group of mammals has hoofs, and so leaves distinctive prints. The hoof prints most likely to be seen by the cross-country hiker are those of deer, sheep and pig. Usually the space between the tracks serves to separate those of the deer from the others. In soft ground or deep snow or when the animal slips somewhat, the two small toes or hoofs on the back of the foot, the "dew claws", leave their mark. In the case of deer these dew claws leave marks some distance behind the regular hoofs, but in the shorter-legged mammals, like the sheep and pig, the prints of the dew claws fall closer to the others. The pronghorn antelope is peculiar among native hoofed mammals in having no dew claws. Sheep wear special shoes designed for mountain climbing. They have a rounded, rubbery pad on the bottom of each toe, making a non-skid tread, and the sides of the hoof are hard and sharp, serving to cut toe-holds in the thin soil of mountain paths. Sheep tracks show this hardened hoof edge especially well on the back and outer sides of each print. The goat foot and track much resemble those of sheep, but the sharp edge extends along the inner



TURTLE (YOUNG)



FROG

side of the hoof as well as along the back and outer edges. Goats with limited range often have these horny edges overgrown and turned inward over the central pad. The pig's foot is rounded and softer, and leaves a wider and shorter track than other hoofed mammals, with no indication of sharp edges at the rear. Also, like all marsh-loving mammals, the pig's fore and hind feet seldom fall on the same spot or in alignment with each other, while deer and sheep tracks usually show fore and hind feet "registering" or in the same line. The track of the moose, largest native hoofed mammal, can be readily told from that of a cow of equal size by the long, pointed hoof marks, a single hoof being about seven inches long and only about one-fourth as wide.

A few mammals have peculiarities in their pedal extremities that make every print sign its maker's name. One of these is the muskrat. Its huge hind feet, broadened and webbed for swimming, leave large prints that do not appear to belong to the same animal as do the small prints of its front feet. Beaver and otter also have paddle feet, although there is less difference between the size of the front and hind footprints. The heavy body of the beaver gives it a strong tendency to toe inwards, the third toe of each foot almost touching a straight line through the center of the series. The otter, because of its long body, leaves a running track of bunches of four prints and a walking track of a close and sinuous series of prints. Another mammal with a telltale signature is the opossum. On each hind foot it has a large, opposable big toe, without any nail or claw. This toe, so useful in climbing, leaves an odd, thumb-like imprint at each step.

The other mammals may be grouped according to their gait. Those with long hind legs bound, so that their tracks fall in groups, the hind feet usually coming down together and falling ahead of the front feet, which serve only for support. Rabbits, squirrels, chipmunks and some mice show this. Jack rabbits do not quite pair their hind feet, while cottontails and squirrels usually do. Climbing mammals usually keep the front feet side by side when running —thus the track of the squirrel can be told from that of the rabbit. Another separating factor is the habit of the squirrel of running in a bee-line from the base of one tree to the next, while the rabbit usually steers a course in the open. The friction pads of the squirrel's feet often leave very distinct indentations. The details of the rabbit track are usually blurred by the hair between the toes, which is especially long in winter. The individual prints of the chipmunk are much like those of the squirrel, except in size, but the usual running pattern shows one fore foot somewhat ahead of the other. Several kinds of mice with climbing habits or with long hind legs leave tracks arranged much like those of the squirrel.

Some other mammals are short-legged and have either wide, heavy bodies, as badger, porcupine and beaver, or long, slender bodies, as otter, mink and weasel. Both groups, when unhurried, leave a well marked trail with many

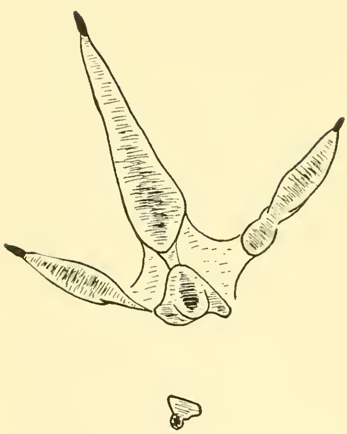
BEETLE

(CALOSOMA)

2"

CROW

(RIGHT FOOT)

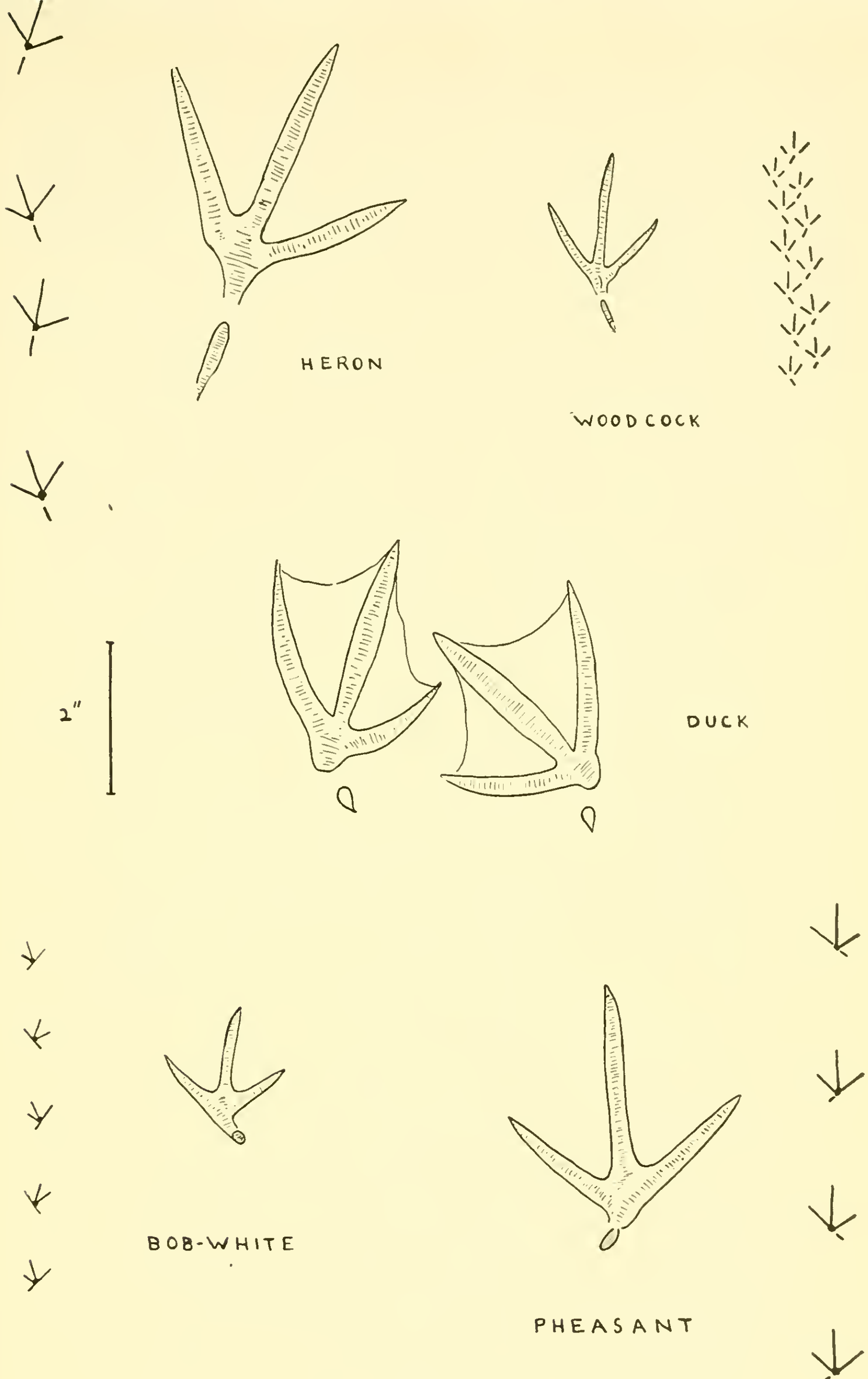


TURKEY

(RIGHT FOOT)

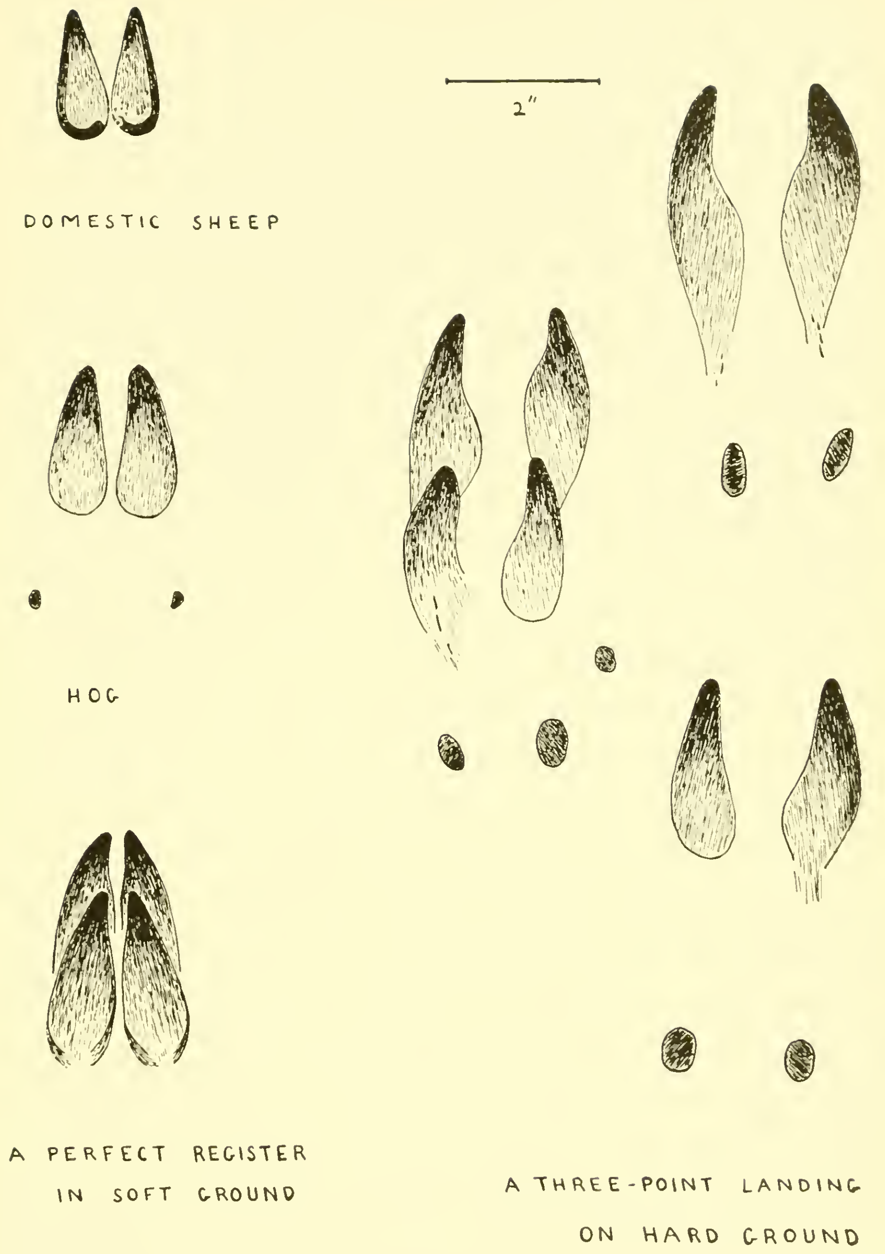
LIZARD

(SCELOPORUS)


HERON
WOODCOCK
2"
DUCK
BOB-WHITE
PHEASANT

close footprints. The heavy-bodied ones toe inwards decidedly. The long-bodied ones, when in a hurry, bound along, leaving groups of four prints. The mink trail can often be distinguished because it frequently shows a "three point landing", the hind foot of one side falling almost exactly on the spot just vacated by the fore foot of the same side. The mink usually goes right into every hole or burrow it comes to, while the weasel usually goes on several circles of inspection over and around any such spots. The skunk, although a member of the mink and weasel family, seldom leaves similar tracks. Its reliance on its powerful gas defense and its adoption of a diet made up mostly of insects have relieved it of the necessity for speed or stealth. The creature shuffles along with many short steps and drags its long, insect-digging front claws in a characteristic trail. In its feeding grounds the many conical burrows, an inch or more wide and deep, show where it has unearthed white grubs or cutworms and are additional flourishes to its autograph. The tracks of the porcupine look surprisingly large for an animal of its size, and the stiff hairs around the foot often increase the size of the track, so that it is sometimes mistaken for that of a bear cub. If toe and claw prints show, the forefoot of the bear has five and that of the porcupine only four. Both have five toes on the hind foot. The porcupine in its normal gait toes inwards far more than does the bear. The locality is often a good indication as to the animal. The badger is a mammal of the open prairies; the porcupine is found in or near trees, where barked or girdled limbs show its feeding ground; otter, beaver and mink are usually near water; skunk and weasel are likely to be found around brush piles, old straw stacks and deserted buildings.

Most of the other mammals leave tracks similar to those of the domestic cat and dog. The fore foot is wider than the hind, which is often longer. The mammal picks footing for its front feet and then steps so that the hind feet fall on, or almost on, the same spots. The cat has retractile claws designed to make no noise as its creeps up on its prey, so that no claw marks show in its tracks. Cougar, lynx and bobcat tracks are similar, except in size. The cats have rounded, fleshy toe pads, each pad, as well as the whole group, making an almost circular imprint. Another peculiarity of the cat family, especially marked in the house cat, is the way in which its tracks approach a straight line, almost giving one the impression that it has but a single foot. The dog's claws are not retractile, as anyone can testify whose pet canine has the habit of promenading on a linoleum or wood floor, so that there are definite claw marks in its tracks. In its hunting it depends more upon speed than upon stealth, and so is less careful to place the hind foot exactly upon the track of the fore foot. Since its lacks the balance and narrow chest of the cat, its tracks are not so nearly in one line as are those of the cat. Wolf and coyote leave tracks almost identical with those of the dog. The only good way to distinguish them is to follow the trail and notice whether the approach to an object of interest was direct, as



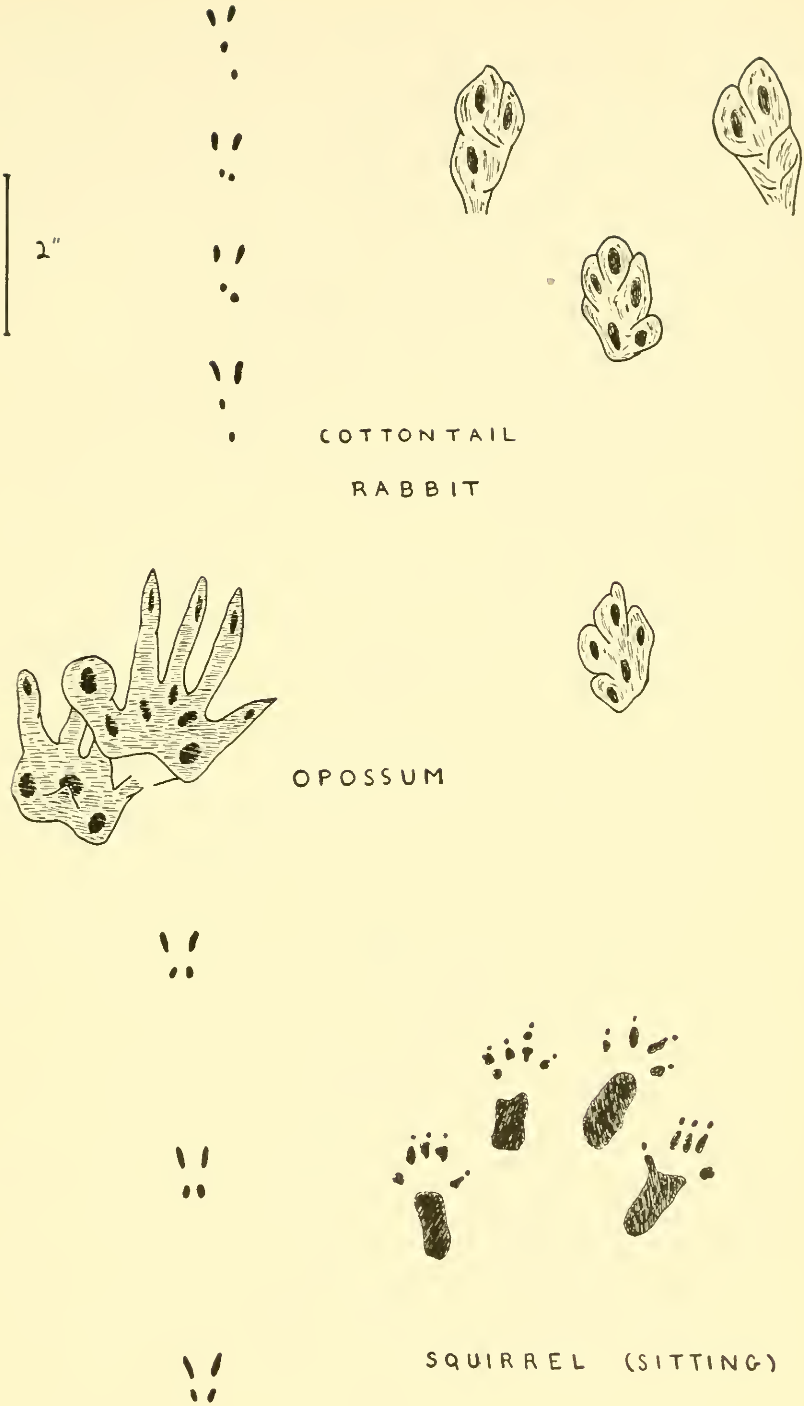
VIRGINIA DEER

a dog goes, or a more cautious, circling approach, which is typical of wolf or coyote. The claws of the fox cannot be fully retracted, so that its tracks show some evidences of claw marks. Its tracks are considerably farther apart than those of a dog of the same size and line up more nearly like those of the cat. In deep snow its large tail also leaves an occasional imprint. All these animals show the print of only four toes on both fore and hind foot.

Bears and raccoons walk flat-footed or plantigrade and therefore leave tracks resembling those of the human hand and foot. The bear frequently tiptoes, however, and then leaves what might easily be mistaken for a cougar track, unless the fifth toe and the claw prints were noticed.

The very small mammals, such as mice and shrews, may be best tracked after a light snowfall or in fine sand or dust. The climbing mice, such as deer mice, leave a pattern like that of a miniature squirrel, when they travel fast. The more terrestrial species, such as the meadow mouse and the house mouse, rarely pair their fore prints, and usually leave irregular groups of four prints. The shrews leave a variety of trails where they cannot tunnel. A common shrew pattern is a double one of staggered prints, but when the creature hurries the footprints often fall in pairs. If tracking conditions are ideal, the tail may leave a print, especially if the shrew has backed up, as at such times it feels its way with its tail. If snow or dust be a little deeper, the stout body, scarcely lifted above the ground by the short legs, may plow a furrow in which the footprints can be seen.

Some caution should be observed in attempting to identify animal tracks, especially in series. Most mammals seem to have as many gaits as a high-school saddle horse. In most published accounts one will find described either the most common gait or one which, although not the usual, is distinctive. For example, the skunk tracks most often figured in such accounts are those in which four prints fall in a diagonal row. This peculiar arrangement is rarely made by any other mammal, and it is made by the skunk only when he gallops. The more usual gait is a shufflling walk, with two rows of tracks, fore and hind foot of each side falling fairly evenly spaced. Rabbit and squirrel may pick their way across mud in short steps, leaving a series quite differently arranged from the usual hop. Mouse tracks offer another common example of varying gaits. In rapid movement over open areas the more climbing of the mice, such as the deer mouse, leave a pattern much like a miniature squirrel track, but when foraging their tracks may fall more like those of the meadow mouse and other poor climbers, which do not pair the tracks of their front feet. After a light snow the beginner will do well to watch for variations in gait in dog tracks across some open area. He may find the normal pattern of a staggered row, the bunching in fours usually typical of the weasel group, and even a series of rabbit-like pattern, where hind legs were thrown around and before the fore legs. Caution should be observed in regard to tail print. Only a few mammals,

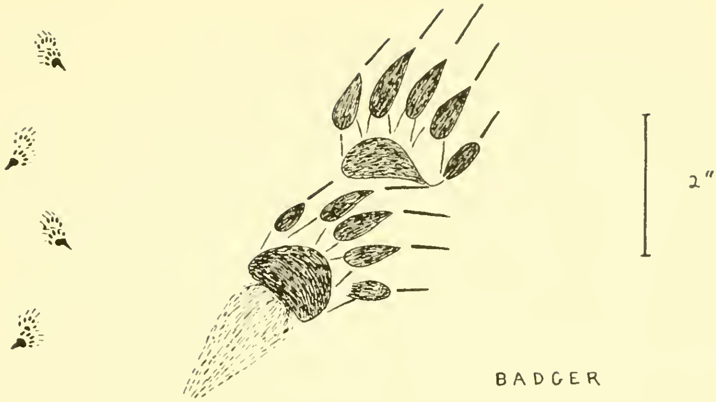

2"
COTTONTAIL
RABBIT
OPOSSUM
SQUIRREL (SITTING)

of which the muskrat is an example, usually show the mark of a dragging tail in the print series. Most mammals drag their tails only when moving very slowly. As soon as any speed is reached, the tail serves as a balancing and steering organ and is raised clear of the ground. Contrary to the impression given by sketches sometimes used in illustrating tracks, the common rat, for example, only rarely leaves a tail print, unless he pauses in his journey. As most hunters know, only a tired fox will lower his tail enough to leave more than an occasional print, except in deep snow.

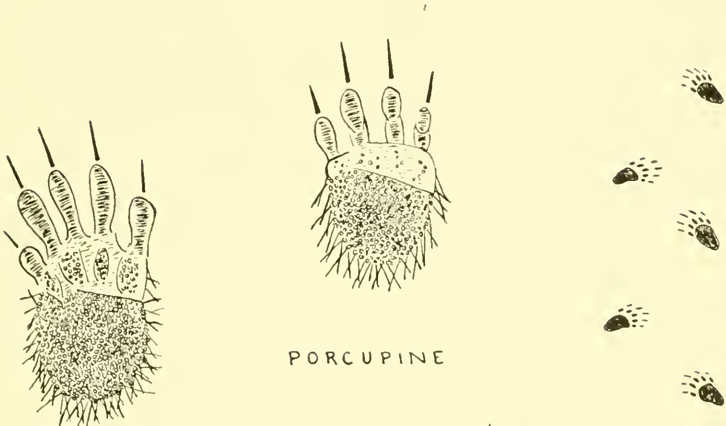
Indications other than footprints often supply additional clues. The dog family commonly scratch the ground around their calling places. The cat and the bear groups claw on tree trunks and leave well marked scratches. The bears also break open rotting logs or stumps in search for insects. In autumn male deer relieve their itching and clean their antlers by rubbing them on trees and shrubs. Food fragments also tell a story. Rabbits and mice, with good upper as well as lower incisors, cut twigs as cleanly as a knife. Deer, lacking upper incisors, leave a somewhat ragged cut. Beavers cut down trees, while porcupines, squirrels and mice usually gnaw off the bark and leave the trees standing. Red squirrels commonly cut off twigs bearing green pine cones, acorns or apples, while gray squirrels rarely do so, except for an immediate meal. Gray squirrels cut nutshells into pieces to get the kernels, red and flying squirrels make a ragged opening in each shell, while mice usually cut a smooth opening in each side. Shrews commonly remove the apex from snail shells in order to eat out the occupants.

Bird tracks are common, but lack the individuality of mammal tracks. Small birds that spend most of their time in trees keep their feet together when on the ground, and hop instead of walking. The larger perching birds usually walk, but sometimes vary the gait with hopping. Even the crow may occasionally be seen hopping, generally aiding the process by flapping his wings. The crow track can usually be recognized by the combination of large size, long hind toe, and unequal spreading of the front toes. Webbed feet and the extreme tendency to toe in mark the tracks of ducks. The large print of the heron, with its widely spread toes, is common along pond edges. There also may be seen the tracks of shore birds such as sand-pipers, peculiar in showing no print of rear toe. In muddy marshes the woodcock patters along and leaves a typical, close grouping or lace-like design of tracks, punctuated here and there with round holes where it has plunged its pencil-like beak into the mud to probe for worms. In the woods large tracks may be left by grouse, partridge and pheasant, the pheasant differing from most other large birds because it points its middle toes directly ahead instead of inwards.

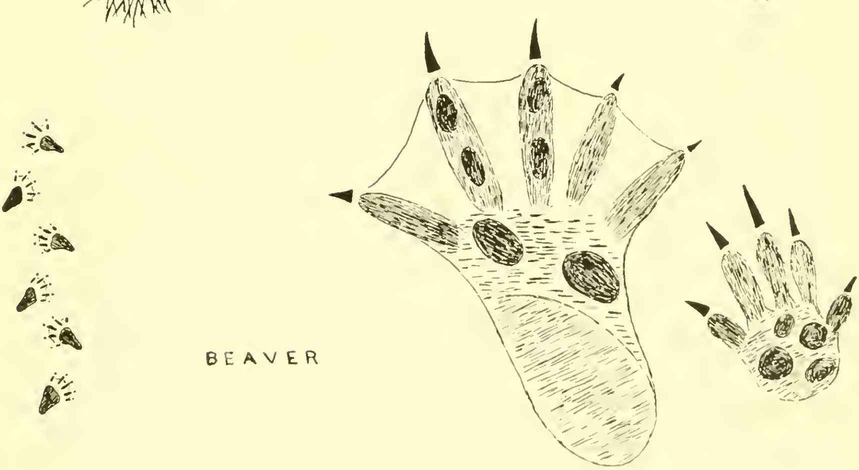
Sometimes conditions are right to record the tracks of the turtle as it holds its shell aloft and with slow and short steps leaves two curious, parallel rows of tracks, spaced about as far apart as its shell is wide. If it is a young



BADGER



PORCUPINE



BEAVER

turtle, or a snapper of any age, its long tail is likely to leave its mark also. The dainty, spider-like prints of frog or toad hands and feet are sometimes visible, where it has journeyed from pond to pond. Even the clams crawling on the lake bed leave telltale furrows, and a silvery ribbon of mucus shows where the snail or slug has wandered.

On the fine sand of dunes and deserts tracks are often abundant. Many of them are likely to be insect tracks, especially beetles. Six legs, some pushing and some pulling, often leave most curious and complex, lacework paths. The sand-dwelling lizards usually have long, widely spread toes, which leave puzzling designs. The puzzle increases when the series starts and stops abruptly, unless one remembers that some of these animals may dive into the sand for shelter and may "swim" through it below the surface for several feet. As with mammals, the tail may be dragged at low speed, but is often held aloft when the pace quickens. Snakes often leave definite tracks in sand. Rattlesnake hunters often profit by the crepuscular habits and follow up the trails in the early morning. Most snakes leave a sinuous furrow, the direction of travel indicated by the sand piled up at the back of each curve. The side-winder, a desert rattlesnake, leaves a series of diagonal but unconnected, straight furrows, the direction of travel indicated by a hook at the rear end of each furrow.

Tracks can usually be photographed to show details only when the sun strikes them at such an angle as to leave definite shadows, which happens only in early morning or late afternoon when the light is seldom bright enough for good pictures. If one has sufficient patience, lamp black or similar fine powder may be sifted into the depressions and, if the wind permits, good pictures obtained when the sun is high—but a calm day, a steady hand, and extreme care and patience are required. For snow pictures a yellow filter aids in recording contrasts.

Casting in plaster is the best method of preserving or duplicating individual animal autographs, the original mold being done either in plaster or in wax. The chief difficulty usually lies in deciding which particular print best shows all the desired details. The easiest method is to find the tracks in mud and, by the aid of candle ends, to fill one with melted wax. As soon as the wax has hardened, it and some of the mud around it can be taken up and carried home, where the mud can be removed by gently washing in cold water and brushing with an old toothbrush. Then the wax block or mold should be inverted and slightly sunken in a bed of fine, wet sand, and retaining walls built around and backed by more wet sand. Sections of paper cartons, such as are used for packing salt or ice cream, make excellent walls, although pieces of cardboard will serve, if well banked with damp sand on the outside and at the corners. A quantity of water about equivalent in bulk to the size of the cast desired is now taken and plaster-of-paris sifted in until a mixture about like


DEER MOUSE
MINK
2"
MUSKRAT
NORWAY
RAT
SKUNK


FOX
CAT
2"
WOODCHUCK
RACCOON

thin pancake batter results. Much stirring should be avoided, as this causes bubbles which remain as unwelcome holes in the cast. This mixture is then poured over the wax and allowed to stand for an hour or more. Then the block can be lifted, the sand washed off, and block and embedded wax dropped into a pan of boiling water. The water should be kept hot until the wax has all melted and risen to the surface. When cool, the film of wax may be broken from the top of the container and the cast taken out and dried. It should be a perfect reproduction of the original track. A coat of paint may be applied to the cast, after it is dry, and, if desired, another color applied in the hollows of the print.

The drawback to the wax mold is that only one cast is possible. If more are desired, the original field work must be done in plaster. Sticks or mud will serve as retaining walls, and the plaster must be given plenty of time to set (it will become warm and then cool again in the process) before it is lifted. After washing, it must be waterproofed with several coats of oil or hot vaseline, or by boiling it in melted paraffin. Then any undercuts or places which, from their shape, would not separate easily from the cast to be made should be filled out with modeling clay or plasticine. The casting is handled just as with the wax mold, but the block must be allowed to dry thoroughly before any attempt is made to separate the two pieces. Then they should be tapped lightly, and, if the undercuts were properly filled and the mold well oiled, they should separate, leaving a perfect cast and the original mold ready for re-oiling and use in making another copy. To separate large blocks one can sometimes start small nails all along the line of junction between the two and tap them gently in sequence with a hammer.

Plaser-of-paris can be bought in any paint or hardware store for about five cents a pound. It must be kept dry until used. If it begins to warm or to set before one is ready to pour, it is useless and should be thrown away. Adding more water will not help it. Plaster molds must be waterproofed and oiled before each cast is made, or mold and cast will enter into such a union that one or the other must be sacrificed and broken away piece by piece.

Tracks in the snow are difficult to cast, impossible if the snow is soft and the temperature above freezing. If colder, one can use ice water to mix the plaster, or add snow to the water used, and flow on a rather thin mixture from the side. A thin plaster mixture, flowed on from one side, usually works well on tracks in dust or fine sand.

A good collection of animal tracks is a worthy achievement and makes an interesting display. Collecting tracks can be recommended as an entertaining and instructive hobby, not injuring the wild animals and not requiring a license or the expensive equipment or ideal conditions necessary for photography.

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